TREATMENT OF ACUTE POLIOMYELITIS

Second Edition

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Edited by

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From the

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FOREWORD

THIS SYLLABUS is neither the first nor the last word in the treatment of poliomyelitis. The frontispiece suggests that poliomyelitis has been recognized for as long as 3250 years. Principles enunciated here reflect our own experience during four years of almost exclusive attention to the management of acute and chronic poliomyelitis and are synthesized with the contributions of others who have dealt with this problem.

The material was prepared as a teaching aid to demonstrate the many inter-related facets of modern poliomyelitis care, which indeed follow the general principles of comprehensive medical management. As a compendium it represents aspects of treatment which have evolved from the co-operative endeavors of the many medical disciplines represented in a respiratory center. The concise format is designed to emphasize the positive and practical considerations in the care of the patient. As a synthesis of experience in poliomyelitis care it necessarily reflects the local practices of those brought together to fulfill the broad needs of the patient. These center around expectant treatment as determined by premonitory signs.

It is hoped that it will have some usefulness in guiding and encouraging that careful individualization which is the constant requirement of medical practice.

The editor expresses sincere appreciation to all who collaborated in the preparation of the syllabus and especially to Doctors Hebbel E. Hoff and Russell J. Blattner for invaluable guidance and encouragement. Miss Laura Smith deserves special acknowledgment for her months of diligent effort in assisting the editor in collecting, preparing and assembling the syllabus.

August 15, 1954
Houston, Texas

WILLIAM A. SPENCER, M.D.

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TREATMENT OF ACUTE POLIOMYELITIS

ULTIMATE DIAGNOSIS OF 1000 SUSPECTED POLIOMYELITIS ADMISSIONS

S.W.P.R.C.
1950-1954

	Number	*Per Cent*
Non-Poliomyelitis	151	15%
Non-Paralytic Poliomyelitis*	258	26%
Paralytic Poliomyelitis	591	59%
Total	1000	100%

* Diagnosis not changed on 1 year follow-up

All who have had experience with infections caused by the poliomyelitis virus are aware of the many complexities encountered in diagnosing the disease. *These are greatly enhanced by pressures exerted on the physician* by an apprehensive public. However, there is no infallible method available at the present time for making a definite diagnosis of poliomyelitis during the earlier phases of the infection

Diseases most commonly simulating poliomyelitis include: The various encephalitides and meningitides, infectious neuronitis, cerebral and spinal neoplasms and abscesses, pulmonary infections, specific diseases of muscles, bones and joints, and acute emotional disturbances *such as hysteria.*

The list of specific diseases which can be confused with acute poliomyelitis is long and varied. Nonetheless, this protean disease has certain clinical features which are sufficiently consistent to merit emphasis.

FINAL DIAGNOSIS OF NON-POLIOMYELITIS ADMISSIONS

TOTAL 151

78 CNS INFECTIONS

27 encephalitis etiol. not det.
6 mumps encephalitis.
1 pertussis encephalitis
1 post-vaccinal encephalitis
1 herpes zoster encephalitis.
1 post-rabies vaccinal encephalitis.
10 pyogenic meningitis.
5 lymphocytic choriomeningitis.
3 tuberculous meningitis.
1 herpes simplex meningo-encephalitis
1 arachnoiditis.
4 cerebral abscess
1 acute pyogenic cerebritis
1 CNS syphilis.
11 infectious neuronitis
3 Coxsackie virus infection?
1 tetanus.

16 OTHER CNS DISORDERS

4 brain tumor.
4 cerebral vascular accident.
1 idiopathic epilepsy.
1 infantile hemiplegia.
1 acute cerebellar ataxia.
2 acute meningo-myelitis etiol. undet
1 spinal cord neoplasm.
1 general muscular rigidity.
1 post-partum post L. P headache.

26 MISCELLANEOUS INFECTIONS

3 pneumonia.
2 influenza.
2 U. R. I.
2 roseola.
3 otitis media.
1 tonsilitis.
1 sinus infection.
2 gastroenteritis.
1 infectious mononucleosis.
9 infection etiol unknown.
1 serum sickness

31 OTHER

2 rheumatoid arthritis.
1 arthralgia
1 rheumatic fever.
1 sprain-lumbar muscles
1 trauma-left arm.
1 neuropathy.
1 cervical adenopathy.
1 tenosynovitis.
2 infantile scurvy.
7 hysteria.
1 angioneurotic edema
12 not determined.

The above diagnoses were those made on patients admitted to the hospital following outpatient admission screening in most instances. Careful historical and physical examination frequently eliminated many non-polio admissions

ULTIMATE DIAGNOSIS OF 944 POLIOMYELITIS CASES

S.W.P.R.C.
1950-1954

	No. Patients		Per Cent	
Non-Paralytic	267		28	
Paralytic	677		72	
TOTAL POLIOMYELITIS		944		100

Spinal Type	477		71	
Bulbar	69		10	
Bulbospinal	131		19	
TOTAL PARALYTIC		677		100

Paralytic Poliomyelitis		677		100
Severe Poliomyelitis	246		36	

Severe Poliomyelitis		246		100
*Fatal Poliomyelitis	45		18	

* Including D.O.A.'s

The percentage of "reported" poliomyelitis patients with the non-paralytic form of the disease varies from 30 to 60 per cent. Because of this, comparative mortality figures are valueless if non-paralytic patients are included. The actual incidence of non-paralytic disease in a hospital experience depends upon: variability of the disease, diagnostic criteria, admission policy and thoroughness of the follow-up evaluation. The low incidence of non-paralytic disease in this example is a result of admission screening and the centralization of severely involved patients in an acute treatment center.

Severe disease is not necessarily synonymous with "bulbar" poliomyelitis if all of the conditions posing a serious threat to life are included.

DIAGNOSTIC CRITERIA FOR ACUTE POLIOMYELITIS

SUGGESTIVE

- Fever of moderate degree without coryza, cough or diarrhea.
- Meningismus—stiff and painful neck and back—inability to flex spine which is "poker-like."
- Head drops back when shoulders are lifted
- "Tripod" sitting position.
- Headache.
- Malaise out of proportion to physical findings.
- Vomiting
- Muscle pain and tenderness—especially trunk and hamstrings (not unilateral).
- Reflexes obtainable, occasionally hyperactive.

CONFIRMATORY

- Flaccid muscle paralysis—often asymmetrical and regional with involvement of several muscles of the same segment.
- Absent tendon reflexes in the affected areas.
- Abnormal spinal fluid: cells more than 10 usually less than 500/cu. mm ; polys early, lymphs later, Pandy positive, slight to moderate increase in protein content; normal sugar content; no bacteria on smear and culture (less 5% of CSF normal in acute phase).

POSITIVE

- Isolation of virus in the presence of the above.
- Increasing antibody titer during the course of the disease.

A definite program of management is indicated by the acceptance of poliomyelitis as a probable diagnosis. It is extremely important to establish the course of the disease by careful observation. The detection or anticipation of impairment of those body functions that determine survival depends upon such evaluations of the patient. Beware of exhausting the patient just for the purpose of elaborating the diagnosis

EARLY TREATMENT OF UNCOMPLICATED POLIOMYELITIS

- Careful constant observation of those patients with signs of serious *poliomyelitis*.
- Supplement observation with careful measurement of the vital signs of temperature, pulse, respirations and blood pressure.
- Maximum rest without sedation.
- Combat dehydration and maintain fluid and electrolyte balance.
- Careful comfortable positioning of the patient with gentle physical measures to relieve pain or discomfort and to prevent deformities.
- Reserve the use of antibiotics and chemotherapeutic agents for secondary infection and pulmonary complications.
- Strict bed rest for 7 to 10 days.

Refinements and alterations in this program of management are directed by the degree of involvement and the presence of complicating factors such as dehydration and nutritional disturbances.

There is no specific therapeutic agent which has been demonstrated to be capable of altering the course of motor-neurone involvement. It appears likely, that undue travel, exertional fatigue, profound and untreated metabolic disturbances, and impaired respiration may seriously compromise the acutely ill patient.

SIGNS AND SYMPTOMS OF SERIOUS POLIOMYELITIS

SUGGESTIVE

- History of unusual physical exhaustion during prodromal phase.
- Pregnancy.
- Rapid onset and progression of paralysis.
- *Paralytic involvement of the shoulder girdle.*
- Involvement of any cranial nerve.
- "Toxic" appearance with flushed facies—perioral pallor and conjunctival suffusion
- Irritability—restlessness—fitful sleep—apprehension.
- Higher temperature elevation without marked diurnal variation.
- Tachycardia.
- Moderate hypertension.
- Nystagmoid—jerky ocular movements on lateral gaze and fixation (opsoclonia).
- Change in sensorium to severe anxiety—lethargy—confusion and unconsciousness.

CONFIRMATORY

- Respiratory muscle paralysis.
- Impairment of the swallowing mechanism.
- Disturbances of vital autonomic and respiratory regulation.
- Pulmonary complications

Recognition of serious poliomyelitis is not necessarily clear cut in the early stages of the infection. An apparently mild illness may progress rapidly to serious proportions. For this reason continuous observation of all patients with any of the suggestive signs and symptoms is imperative. Do not mask crucial symptoms or depress protective reflexes by sedation. Therapeutic manipulations such as application of hot packs are more exhausting than beneficial in such cases at this stage.

FREQUENCY OF SERIOUS COMPLICATIONS IN 246 SEVERELY ILL POLIOMYELITIS PATIENTS

S.W.P.R.C.
1950-1954

*Complication**	*Incidence**	*% Patients*
Total severely ill patients	246	100
Respiratory muscle paralysis	180	73
Impairment of swallowing	132	53
Disturbances of circulatory and respiratory regulation	125	50
Pulmonary edema	9	4

* Combinations of these complications in a single patient are not indicated in the above chart

The incidence of severe poliomyelitis varies from epidemic to epidemic. This is probably a result of differences in the virus and in host susceptibility. The occurrence of serious complications in 36% of paralytic patients is somewhat larger than the usual incidence of 20-30% because of selective admission. Nevertheless, the frequency of such conditions in the course of the acute illness emphasizes the importance of their detection and treatment for the preservation of life. This is a separate problem from the ultimate disability which may result from the residual muscular paralysis.

SIGNS AND SYMPTOMS OF RESPIRATORY MUSCLE PARALYSIS

EARLY RESPIRATORY MUSCLE INVOLVEMENT IS NOT OBVIOUS

SUGGESTIVE

- Involvement of the pectoral musculature especially the deltoid group.
- Increase in respiratory rate.
- Shallow respirations.
- Decreased ability to protrude abdomen (diaphragm).
- Diminished elevation of thorax on deep breath and abdominal splinting (intercostals).
- Decreased or unequal upper abdominal movement with "sniffing" (diaphragm).
- Paradoxical abdominal or thoracic movement on deep breathing
- Inability to tighten abdominal muscles on raising head.
- Poor or absent cough (abdominal muscles).

CONFIRMATORY

- Absent breath sounds on auscultation
- *Fluoroscopic evidence of diminished or absent range of move*ment of diaphragm and intercostal–diaphragm lag–unusual tenting
- Decreased vital capacity below minimum normal values

Respiratory muscle paralysis is the most common serious complication of poliomyelitis Early detection is essential: (a) to accustom the patient to respiratory assistance, and (b) to prevent asphyxia.

Artificial respiration is eventually necessary in 80 per cent of all patients with respiratory muscle paralysis. Why wait for profound asphyxia to confirm *the presence of respiratory failure? Anticipate* and prevent trouble by early respiratory assistance. There is no evidence that artificial respiration increases respiratory muscle paralysis. Artificial respiration does diminish the work of breathing Asphyxia may produce irreversible deterioration. The onset of asphyxia is insidious and its symptoms may not be alarming until too late. Don't blame such symptoms on poliomyelitis until asphyxia has been excluded by effective respiratory assistance.

SIGNS OF PROGRESSING RESPIRATORY IMPAIRMENT

DECREASING RESPIRATORY MUSCLE EFFORT IS THE INDICATION FOR RESPIRATORY ASSISTANCE

GENERAL SIGNS

- Increasing respiratory rate.
- Decreasing respiratory depth.
- Increasing pulse rate.
- Rising blood pressure (slight to moderate).
- Fatigue—slight pallor.
- Poor tolerance to examination and nursing procedures.

SPECIFIC

- Breathlessness.
- Inability to take deep breath on command.
- Any change in breathing pattern.

LOOK

- Flaring of nostrils.
- Fluoroscopic evidence of poor pulmonary aeration (diminution or absence of diffuse pulmonary illumination on quiet breathing).
- Usage of accessory muscles—(uncommon until very late).

LISTEN

- Shortened duration of speech
- Diminished volume of vocalization—weak cry.
- Inequality or absence of breath sounds.

MEASURE

- Decreasing ability to count on one breath.
- Decreasing vital capacity which is below minimum normal values.

There is no doubt that clinical judgment and experience are important for the use of these signs in determining the optimum time for introduction of artificial respiration On the other hand the determination of minimum effective breathing is so inexact and so near to respiratory failure that there is no reason to prove this by withholding assistance.

Early elective artificial respiration usually benefits the patient and has not been difficult to discontinue in the few patients who need it for brief periods or who do not progress to extensive respiratory muscle paralysis.

INITIAL ADJUSTMENT OF THE RESPIRATOR

NEVER LEAVE PATIENT UNATTENDED!

SUGGESTED SETTING FOR THE TANK RESPIRATOR

Age/yrs	*Rate/min*	*Pressure/cm H_2O*
0-2	30-40	-12+0
2-5	24-35	-14+0
5-10	24-28	-15+0
10-15	20	-15+0
Adult	16-18	-14 to -18

The values for the initial adjustment of the respirator are given only as a starting point and are empirical Some clinicians prefer to use slight positive *pressure on expiration. Careful pressure recording, however, reveals that* most tank respirators always have some positive pressure on expiration when used with a patient. This probably results from unavoidable and relatively large inboard leaks during inspiration around the collar at the neck. (See General Considerations in Maintenance of Respiratory Equipment.) In our experience positive pressure on expiration in excess of 5 cm. of water is uncomfortable

Individualization of respirator settings, especially pressure adjustment has been simplified by the routine measurement of tidal ventilation produced by the respirator. (See Ventilatory Measurements—Tidal Volumes.)

The TANK respirator is the device of choice for artificial respiration in the acute phase of the disease because it is simple, safe and the most effective This is very important because the tank respirator alone possesses the range of ventilatory effectiveness which may be necessary in some severely ill patients and most of the auxiliary respiratory devices such as the cuirass respirators and the rocking bed are not suitable initially for continuous [illegible]

interruption of artificial respiration so the simplest and most effective device must be used. He should not be compromised by nor can he tolerate underventilation. This may occur more easily in the use of auxiliary devices because the adjustments to obtain the required higher pressures are critical, fitting of the shell is difficult to obtain and maintain, and prolonged ac-

RATE AND PRESSURE ADJUSTMENT OF THE RESPIRATOR

FACTORS IN RATE ADJUSTMENT

- Rate is subjectively more important than pressure for synchronization so at first duplicate spontaneous rate.
- Rate is decreased after synchronization to the point above which patient supplements respirator if rate is faster than suggested range.
- If patient is apneic use table values and consider body temperature, faster early rates are not necessary when the patient is afebrile.
- Rapid rate approximating spontaneous rate is essential for coordination with irregular shallow breathing.

FACTORS IN PRESSURE REGULATION

- Tidal ventilation should be proved to be adequate by measurement (see ranges of tidal ventilation).
- Initial values are empirical and should be altered by measurement and the patient's general response when necessary.
- Pulmonary, circulatory complications and tracheotomy require higher pressures for adequate depth of breathing.

The factors used in rate and pressure adjustment are self-explanatory, however, certain features should be pointed out. It is very desirable to let the patient determine the most acceptable rate setting of the apparatus and subsequently, ventilatory measurements should be used to determine appropriate ranges of tidal volume for the rate which is chosen and the pressure which will produce it Minute volume of ventilation has not been emphasized for the reason that suggested tidal volumes are paired with rates which will correspond to those found desirable by most patients and which will achieve at least minimum minute volumes consisted with the needs of "normal metabolism" in the uncomplicated patient. (See Appendix Ventilatory Measurements—Tidal Volumes.)

Proper rate and pressure adjustments are easier to obtain in the cooperative patient. The actual effectiveness of artificial respiration may depend upon this because the patient must set up new patterns of swallowing and glottic coordination for breathing, swallowing and speech For these rea-

sons withholding artificial respiration may lead to a state in which its use is unnecessarily complicated or even ineffective.

In the absence of ventilatory measurements a reasonably satisfactory adjustment can be obtained using the suggested range of rates and pressures and clinical evidence for satisfactory adjustment of the respirator such as outlined on the following page.

EVIDENCE FOR SATISFACTORY ADJUSTMENT OF RESPIRATOR *PRESSURE AND CYCLING RATE*

- Disappearance or improvement in symptoms such as restlessness—sleeplessness—unfavorable changes in the vital signs.
- Acceptance of the rhythm of the respirator with *synchronization.*
- Disappearance of anxious facial expression—patient relaxes with dozing and sleep.
- General *improvement in sensorium and feeling of well being.*
- Demonstration of adequate pulmonary ventilation (see Appendix).

The physician must steer a course between hypoventilation and hyperventilation. Table values for adequate tidal volumes are minimum values, predicted from normal metabolic requirements Measured tidal volumes which clinically appear to be proper for the individual patient are often slightly larger than predicted values Avoiding extremely large tidal volumes will minimize hyperventilation.

By listening over the mouth of the sleeping patient with a stethoscope, and increasing respirator pressure a point will be observed at which unconscious inspiratory obstruction develops as a result of glottis closure. On the other hand decreasing the pressure will often produce restlessness, dilation of the nostrils and spontaneous respiratory efforts. Between these two points proper ventilation may be assumed to occur. Such suggestions as these are of primary importance early in the use of artificial respiration Similarly, early introduction of artificial respiration permits many of the *maneuvers and* guides to be effectively utilized

CONDITIONS COMPLICATING THE USE OF ARTIFICIAL RESPIRATION

- Swallowing difficulty increases the likelihood of pulmonary aspiration.
- Airway obstruction prevents adequate pulmonary ventilation and *must be corrected.*
- Tracheotomy is necessary to achieve adequate ventilation and minimize aspiration in the respirator patient with swallowing difficulty and/or airway obstruction
- Incoordination with the respirator is not a contraindication to artificial respiration if the spontaneous effort is shallow in character and ineffective.
- Most comatose respirator patients require a tracheotomy to preserve an unobstructed airway.
- Pulmonary complications are more frequent in apneic respirator patients.
- Hypotension may be unfavorably influenced by artificial respiration.

Artificial respiration does not duplicate the normal breathing mechanism. It can produce adequate pulmonary ventilation in the uncomplicated patient It does interfere with the mechanics of venous blood return during the inspiratory phase in contrast to normal breathing. Abdominal muscle weakness and the subjection of the entire body to the sub-atmospheric pressure of the ventilatory cycle contribute to this effect. Such circulatory effects may be extremely undesirable in the hypotensive patient or when suitable compensatory responses are lacking

The effect of respirator pressure patterns upon both pulmonary gas distribution and blood perfusion is not clear.

The mechanism of heat loss through skin evaporation and radiation may be retarded.

Artificial respiration may impede the removal of increased bronchopulmonary secretions. Upper airway secretions are aspirated into bronchopulmonary segments in the same fashion as with normal inspiratory efforts The patient is unable to cough and the respirator is a poor coughing device The respirator patient's ability to protect himself against aspiration may be ineffective since he is unable to control the cycling of the respira-

tor. This is likely since such protection depends upon coordination of swallowing—glottic closure and respiratory arrest.

Artificial respiration must never be attempted in the presence of an obstructed airway or whenever factors contributing to aspiration have not been prevented or corrected.

SIGNS OF PROGRESSIVE ASPHYXIA

- Circumoral pallor—constricted pupils.
- Poor skin color and circulation (mottling of the skin).
- Profuse sweating—especially on the forehead.
- Deterioration of well being and responsiveness.
- Progressive restlessness—inability to sleep. Apprehension ultimately leading to a panic state.
- Confusion—delirium.
- Marked dilation of nostrils often with frank dyspnea.
- Thready pulse—occasionally hypertension followed by hypotension.

LATE

- Appearance of facial components of breathing.
- Intermittent cyanosis—hallucinations—panic—coma—persistent cyanosis—death.

Asphyxia should be regarded as a complete failure of the breathing mechanism. The extent to which biochemical alterations of oxygen, CO_2 and hydrogen ion concentration are responsible for these signs is not known. It is clear that biochemical equilibrium is maintained for a surprising period in the face of progressive respiratory muscle paralysis and therefore alterations of these chemical variables must be considered to be evidence of failure of respiration.

The signs of failure of breathing should not be used as an indication for artificial respiration. The early demonstration of decreasing respiratory muscle power is the safest indication.

LABORATORY GUIDES TO RESPIRATORY MANAGEMENT

GENERALLY AVAILABLE

- Determination of pulmonary ventilation and compartments (see Appendix).

SPECIAL STUDIES

- Arterial blood
    - Oxygen content and per cent hemoglobin saturation, pH, CO_2 content and p CO_2.
- *Gas*
    - Expired "alveolar" p CO_2.
    - CO_2 excretion and oxygen uptake.

The value of pulmonary ventilatory measurements and vital capacity determinations has been clearly established.

The special laboratory studies are of indeterminate therapeutic value at the present time. There is no doubt that chemical measurements are much less reliable than careful evaluation of the patient and clinical experience with respiratory disease. Preliminary examination of arterial pH and CO_2 content indicates that alkaline pHs and low CO_2 contents are frequently observed in acute poliomyelitis with respiratory muscle paralysis or even in the absence of involvement.* This is important because of the emphasis which has been placed upon CO_2 retention as a guide to decreasing respiratory muscle function. The reasons are not clear but some features of the acute disease warrant emphasis: The influence of severe apprehension in promoting hyperventilation; the role of metabolic alterations such as increased metabolism leading to high oxygen demand with a respiratory compensation promoting increased CO_2 elimination; the presence of hypochloremic alkalosis; alteration of renal function; and other factors which influence blood gas and hydrogen ion regulation. When CO_2 retention with acidosis is observed in poliomyelitis in our experience it is usually associated with conditions productive of airway obstruction and serious impediment to pulmonary ventilation.

* See bibliography.

It should be noted that venous blood values are of no value and may be misleading

Arterial oxygen saturation is preserved over a wide range of oxygen content especially in alkaline blood so that its determination has minimal value except as an indication of complete failure of respiratory function or as a sign of pulmonary and circulatory complications leading to decreased pulmonary gaseous diffusion.

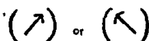
SIGNS AND SYMPTOMS OF IMPAIRMENT OF SWALLOWING

- Complaint of swallowing difficulty (do not test).
- Fluoroscopic demonstration of impaired swallowing with lipiodol.
- Weakness of anterior neck muscles.
- Accumulation of frothy secretions in the pharynx.
- Diminished gag reflex, incoordinate gagging with choking
- Absent or asymmetrical movement of the posterior pharyngeal wall.

NORMAL



ABNORMAL



- Absent or asymmetrical opposition of tonsillar pillars.
- Angle sign—lack of subglossal fullness and contour.

NORMAL



ABNORMAL



- Weak or absent elevation and descent of hyoid and thyroid cartilage against resistance of finger

In most instances swallowing difficulty is a result of bulbar poliomyelitis with involvement of the Xth nerve motor nuclei. However, it is becoming *increasingly* clear that swallowing is an exceedingly complex act that involves elaborate brain stem neuro-regulatory *activity and functional* coordination.

SIGNS AND SYMPTOMS OF IMPAIRMENT OF SWALLOWING

GENERAL

- Hacking—spitting—drooling—fear of recumbency.
- Shallow often irregular respirations—improved after suctioning.

LATE

- Change in appearance—poor color—fatigue—drowsiness—sleeplessness—lack of concern for accumulation of secretions.
- Auscultation of coarse rhonchi and roughness in airflow at the mouth.
- Inspiratory stridor with vocal cord paralysis.
- Cyanotic episodes (too late).

Prompt recognition and treatment of swallowing difficulty is essential to prevent: (a) upper airway obstruction, (b) tracheobronchial aspiration and lower airway obstruction; (c) underventilation resulting from shallow, inhibited and irregular respiratory efforts, and (d) choking with glottic spasm and prompt asphyxia and death. Swallowing impairment should also be considered an extremely serious development in the course of the disease because of the frequent association of serious often fatal disturbances of cardiovascular activity.

Palatal paralysis has not been emphasized for several reasons: (a) in itself asymmetrical or absent movement of the soft palate and uvula produces nasal voice, not swallowing difficulty, and (b) it may occur as an isolated indication of brain stem involvement or be associated with facial motor paralysis and no swallowing impairment or other evidence of severe illness. It remains only as an important sign of extension or localization of the disease to the brain stem (bulbar poliomyelitis).

IMMEDIATE MEASURES IN THE TREATMENT OF IMPAIRED SWALLOWING

REMOVE SECRETIONS AND PREVENT THEIR ACCUMULATION

- Allow only prone and side lying position.
- Use moderate Trendelenburg position (10°-15°).
- Use careful, skillful, intermittent, high vacuum suction or combine constant, low vacuum suction. Avoid gagging and choking—use multiple perforated rubber catheter, metal suction tip or indwelling polyethylene catheters.

ELIMINATE NEED TO SWALLOW

- NO oral feedings, fluid or medications.
- Initiate parenteral alimentation
- Use small, indwelling, nasogastric, polyethylene tube for drip feeding as soon as the patient is afebrile or earlier if course is uncomplicated and not progressive.
- Avoid gastro-intestinal distension (CLAMP OFF NASOGASTRIC TUBE), large volume feedings, gastric retention due to excessive fat in formula to minimize vomiting and aspiration.

The prevention of underventilation and asphyxia is the objective of treatment no matter what methods are employed. These serious and fatal complications appear to be a result of upper airway obstruction, aspiration, lower airway obstruction and irregular, shallow, voluntary inhibited breathing efforts.

The nutritional handicap resulting from inability to swallow can be readily corrected through parenteral routes and by nasogastric tube feeding. On the other hand, liability to other hazards of swallowing difficulty is still present because of the large volume of oropharyngeal and tracheobronchial secretions. Prevention of underventilation and asphyxia without doubt challenges all of the judgment, skill, experience and resourcefulness of the physician. Suitable management of this difficult condition can often be carried out by wise observation of cardinal symptoms and prompt effective treatment in the manner indicated.

CONTRAINDICATIONS TO CONTINUATION OF CONSERVATIVE TREATMENT OF IMPAIRED SWALLOWING

- The likelihood or actual development of respiratory muscle paralysis requiring artificial respiration.
- Inability of the patient's coughing mechanism and the treatment method to remove tracheobronchial secretions.
- Increased liability of the young patient to sudden fatal aspiration.
- The hazard of oral feedings in the infant requiring artificial respiration.
- The occurence of coma and absence of protective reflexes in some severely ill patients requiring artificial respiration.
- Overburdening of personnel and treatment facilities for continuous conservative management of the patient.
- Development of fatigue and exhaustion without sleep or rest from treatment measures.
- Development and rapid progression of swallowing impairment early in the course of severe disease.

These contraindications obviously become more significant as evidence for failure of conservative treatment accumulates.

Conservative treatment may be inadequate and radical surgical measures such as tracheotomy may be urgently indicated depending upon the patient's general condition and the extent of involvement. Unfortunately patients with swallowing difficulty may also have extensive parallel impairment of the central regulation of vital autonomic and respiratory functions which may be irreversible in nature. However, deterioration of the patient's general condition during treatment should not be blamed upon neurologic involvement until underventilation or asphyxia has been prevented or recognized and corrected.

SIGNS OF FAILURE OF CONSERVATIVE TREATMENT OF IMPAIRED SWALLOWING

- Persistence of accumulated secretions—increasing production of secretions.
- Deterioration of general condition—with the appearance of fatigue and exhaustion—lack of concern over inability to swallow.
- Poor color—frequently but not invariably rising pulse rate and blood pressure.
- Persistence of shallow, irregular breathing.
- Inability of the patient's protective reflexes to prevent choking and/or aspiration in spite of conservative measures.
- Pulmonary complications of atelectasis and pneumonitis.

Choking with and without cyanosis, aspiration, evidence of underventilation, and deterioration of the general condition of the patient are not only serious signs of failure of conservative treatment but should be prevented by more radical measures such as tracheotomy. The decision to perform a tracheotomy *should not be lightly entertained but all too frequently* it is utilized too late, after the patient has been seriously compromised Once again a careful course of action must be determined by individualization and consideration of the many factors influencing the efficacy of "conservative" measures. Tracheotomy is not necessarily a simple solution to the many respiratory problems which may be encountered in the management of severe poliomyelitis.

INDICATIONS FOR TRACHEOTOMY

- Failure of "conservative" measures to maintain an unobstructed airway and adequate pulmonary ventilation.
- The occurrence of aspiration and/or pulmonary complications such as atelectasis and pneumonitis in the course of swallowing difficulty.
- Respiratory muscle paralysis combined with any impairment of the swallowing mechanism.
- To permit the adequate management of severe pulmonary complications in the respirator patient.
- For the preservation of the airway in comatose patients.

There is no doubt that tracheotomy is the most effective means of establishing an unobstructed airway. It should be performed skillfully under local anaesthesia, high (first or second tracheal ring) and with dispatch. In general it should be performed only after an emergency airway has been established by endotracheal intubation or bronchoscopy. This is extremely important for the safe performance of a tracheotomy in children and occasionally in the adult patient. Artificial respiration must be continued during the tracheotomy procedure when tracheotomy is necessary in the respirator patient. Anaesthesia bag intermittent positive pressure or the use of a chest-abdomen cuirass respirator is a satisfactory means of ventilating the patient. Oxygen should also be used during the procedure. Not infrequently the likelihood of progressive respiratory muscle impairment in association with swallowing difficulty can be anticipated. Thus earlier and less hazardous tracheotomy can be accomplished before the institution of artificial respiration.

TREATMENT OF CENTRAL DISTURBANCES OF RESPIRATORY REGULATION

- In uncomplicated patients—mild irregularity easily replaced by *voluntary* commands to breathe regularly may disappear spontaneously.
- If irregularity persists and unfavorable changes in vital signs develop ventilatory measurements will usually verify inadequate ventilation hence use—
  - Artificial respiration with assurance of an unobstructed airway.
  - Oxygen therapy.
  - Judicious sedation.
  - Electrophrenic respiration.

  (Artificial respiration *may be necessary for several days to a week* followed by spontaneous recovery.)
- In association with circulatory and other autonomic disorders *prognosis is poor—respiration and circulation must be sustained* by substitute devices and pharmacologic measures.

In the critically ill patient adequate pulmonary ventilation may be achieved *only with artificial respiration. Obviously asphyxia, inadequate* circulation and severe metabolic and biochemical disturbances may be contributory. Correction of conditions such as asphyxia, preservation of blood pressure and maintenance *of fluid and electrolyte balance are important* supportive measures in the desperate situation, although frequently they will not be effective enough to prevent death due to profound hypotension, cardiac failure and arrest, *pulmonary edema, massive intestinal* hemorrhage, renal failure, etc.

In the absence of cardiovascular and other autonomic disturbances—serious threat to life may not *develop, and an excellent recovery may be observed.*

CARDIOVASCULAR AND AUTONOMIC ABNORMALITIES

- SEVERE HYPERTENSION—
  SYSTOLIC PRESSURE MORE THAN { 200 mm Hg—Adult. / 160 mm Hg—Child. }
  Pulse pressure is reduced
- BRADYCARDIA
  Usually of brief duration
- HYPERTHERMIA AND SEVERE CUTANEOUS VASOCONSTRICTION
  Body temperature in excess of 106° may occur with cold, mottled and pale skin which is clammy to the touch. Skin circulation is sluggish and cyanotic
- SEVERE HYPOTENSION—
  SYSTOLIC PRESSURE LESS THAN { 90 mm Hg—febrile Adult. / 60 mm Hg—febrile Child. }
- EXTREME TACHYCARDIA LEADING TO OUTPUT FAILURE—PULSE OVER { 180/min.—Adult. / 210/min.—Child. }
- VENTRICULAR PREMATURE BEATS
  Especially in a series.
- PULMONARY CONGESTION AND EDEMA
  Suggested by marked increase in hilar and lung markings and by characteristic ECG vector clockwise displacement and high, peaked P waves. Edema produces acute respiratory distress and abundant frothy, blood tinged secretions.
- MYOCARDIAL FAILURE AND MYOCARDITIS
  Soft and poor heart sounds with progressive enlargement. ECG alterations
- EMBRYOCARDIA
  (170-180) fast, unmodified and regular heart rate which is usually terminal.
- SEVERE GASTROINTESTINAL DISTENTION—ILEUS

Fatal bulbar poliomyelitis is often associated with progressive elevation of body temperature to intolerable levels, cutaneous vasoconstriction, hypertension and bradycardia, followed by tachycardia and fatal hypotension

or pulmonary edema and respiratory failure. Treatment measures should be employed even though the course of the disease may not be alterable.

These signs and symptoms may be produced by a variety of conditions: brain stem damage; altered brain stem function as a result of nervous or chemical disturbances; changes in vital chemical equilibria of oxygen, CO_2 and hydrogen ion concentration; specific damage to the cardiac muscle, etc. Over-compensatory or harmful body responses resulting from the "stress" of disease or treatment procedures may complicate the situation. It is usually not possible to separate causes. It is more important to prevent or eliminate conditions such as asphyxia which may produce failure of circulation and respiration.

CIRCULATORY AND OTHER CONDITIONS REQUIRING IMMEDIATE TREATMENT

HYPERTHERMIA. Attempt vigorous cooling of the body and cutane-s vasodilation to promote heat loss. Alternately apply warm and cool eets to the entire body. Improve skin circulation by brushing and use 5% cohol intravenously (200-1,000 cc.) as a cutaneous vasodilator. Avoid e use of ice and topical alcohol which may increase vasoconstriction by cessive chilling of the skin.

HYPERTENSION has been effectively treated with the parenteral ad-nistration of Rauwolfia serpentina extracts. The maximum dosage is 80 crograms per kilogram of body weight as the total dose per twenty-four urs. One-half is administered as a stat dose either intramuscularly or in-avenously for most rapid effect (30-120 minutes). The balance is given in to eight hour divided doses. A hypotensive drug which does not render e patient unresponsive to vasopressors must be used since the natural urse of the disease may terminate in fatal hypotension. Digitalis prepa-tions are useful adjuncts and appear to be without harm in the acute culatory failure which accompanies failing cardiac output and ECG idence of impaired cardiac activity.

HYPOTENSION is usually effectively corrected with continuous drip travenous administration of a solution containing 4 mgm. of nor-epi-phrine to 1,000 cc. of 5 or 10% invert sugar in water. The rate of admin-ration is entirely dependent upon the response of the blood pressure hich must be measured at frequent intervals. In some cases its use may be cessary for days to several weeks. Hypotension must be immediately cor-cted in order to preserve central nervous system function and renal tivity.

Pressure adjustments of the respirator designed to promote venous return rough increasing expiratory positive pressure to the same value as in-piratory negative pressure have not been remarkably effective in this con-tion There is no doubt that such a procedure has theoretical and experi-ental merit.

The parenteral administration of ephedrine may be of value and in addi-on it is a potent bronchial dilator.

DISTENSION which may be gastric or generalized will lead to acute spiratory impairment in the respirator patient. It can usually be mini-ized with nasogastric intubation and intermittent or constant suction. ygen administration is of some value and prostigmine subcutaneously in dosage of 0 1 to 0.5 cc. of 1:1,000 solution is particularly effective. Oral edings must be discontinued.

• **PULMONARY EDEMA** has been uncommon. Avoidance of the use of plasma, plasma expanders and whole blood may be an important factor in minimizing pulmonary edema. In poliomyelitis, hypotension is apparently not a result of blood loss, so their use is usually contraindicated. The only exception is extensive blood loss from massive intestinal hemorrhage which is very rare. The slow intravenous administration of aminophylline (100-500 mgm.) in 10-50 cc. of 50% glucose solution may be of value when combined with effective ventilation and satisfactory maintenance of blood pressure. Without doubt heroic treatment may be completely ineffective.

• **MYOCARDIAL FAILURE AND MYOCARDITIS** is best treated with digitalis preparations in conventional dosage. Rapid and large administration of parenteral fluids should be avoided.

CARDIOVASCULAR ABNORMALITIES OF MINOR SIGNIFICANCE

- Arrhythmias–pronounced sinus arrhythmia–wandering pacemaker.
- Moderate tachycardia–rate less than 150/min. in adults, 180/min in children.
- Moderate hypertension–systolic and diastolic.
- Paroxysmal supra-ventricular tachycardia of brief duration.
- ECG abnormalities due to cardiac displacement (abnormal QRS vector in frontal projection, elevated S-T segment, deep Q waves, S_1 S_2 S_3 pattern, etc.).
- Right bundle branch block.

These should be recognized primarily because no treatment is indicated. In addition such findings do not signify a serious prognosis. In a number of cases ECG alterations and circulatory findings are suggestive of the type of body stress occasioned by severe illness and are therefore probably not specific. Prolonged Q-T time and shortened P-R intervals are good examples.

SIGNS AND SYMPTOMS OF PULMONARY COMPLICATIONS

TRACHEOBRONCHIAL ASPIRATION, ATELECTASIS AND PNEUMONITIS

- Deterioration of condition—poor color, loss of appetite, change in mental outlook.
- Recrudescence of fever, frequently polymorphonuclear leukocytosis.
- Change in vital signs, increase in pulse rate, increase in blood pressure, poor peripheral circulation—may be signs of inadequate ventilation.
- Complaint of something in the throat.
- Auscultation of a double expiratory sound with a midpause or click—is noted frequently with atelectasis or tracheobronchial obstruction. Marked diminution in volume of outflow.
- Reduction in tidal volume at high inspiratory pressures reflecting a change in lung pressure volume relationships.
- Radiographic changes in lung fields.
- Aspiration of purulent tracheobronchial secretions.

In some instances frank evidence of tracheobronchial aspiration or atelectasis may be present—shift of mediastinum, displacement of PMI and other findings suggestive of collapse of a lobe. These findings are not uniformly present especially in the respirator patient. Pulmonary complications may occur with surprisingly few clinical signs and symptoms, so should be anticipated as a common cause of deterioration of the patient's condition or of unexplained fever.

PREVENTION OF PULMONARY COMPLICATIONS

PREVENTIVE MEASURES

- Prevent bronchial aspiration of secretions by adequate and careful upper airway suction.
- Frequent change of position—avoid prolonged Trendelenburg.
- Insure adequate humidification of inspired air.
- Attempt to preserve muco-ciliary mechanism. Prevent tracheal drying and crusting. Change tracheotomy tube q 2 days.
- Use artificial cough maneuvers with the vacuum cleaner with any complaint of inability to clear throat or evidence of accumulation of secretions.
- Use intermittent deep breath—intermittent abdominal splinting to promote thoracic expansion.
- Obtain serial smears and cultures for determination of predominant organisms in tracheobronchial tree.

Preventive measures are extremely important. Nevertheless the respiratory poliomyelitis patient has an increased liability to pulmonary complications even under ideal circumstances. Causative factors include: (a) easy aspiration of contaminated secretions because of absent effective reflex protection of the airway; (b) inability to remove secretions, loss of coughing ability, failure of ciliary mechanism, increased amount and viscidity of secretions; (c) infrequent maximum lung expansion such as occurs with sighing and exercise, and (d) alterations of air distribution in the lungs and changes in pulmonary blood flow as a result of prolonged immobilization in the supine position, respiratory muscle paralysis and artificial respiration.

In any case the preventive measures should be routinely employed and prompt adequate treatment should be carried out. Antibacterial therapy should be directed by the sensitivity of the predominant organism. Routine prophylactic antibiotic therapy or chemotherapy may be inadvisable because the ordinary bacterial flora are replaced by resistant organisms. The development of a pulmonary complication with this type of secondary infection is obviously most difficult to treat.

TREATMENT OF PULMONARY COMPLICATIONS

- Treat infection early—specifically and *adequately.*
- Repeat tracheobronchial aspiration. Less traumatic bronchoscopy may be done through the tracheotomy when usual suction is ineffective.
- Correct for the effect of these complications in diminishing ventilation and increasing pressure requirements in the respirator. Prove adequacy of tidal exchange.
- Use humidified oxygen and/or steam therapy.
- *Make frequent changes in body position*—postural drainage.
- Ephedrine (SC) 30 minutes prior to endotracheal suction—occasionally prolonged dosage may be necessary.
- Treat myocardial insufficiency *secondary to extensive pulmonary* complications with digitalization.
- If hemoglobin is below 10-12 gms. use repeated small blood transfusions.

In addition to the measures previously outlined certain features are important in the satisfactory management of these complications. They include: (a) frequent bronchoscopy which is necessary for persistent atelectasis and whenever *underventilation cannot be corrected by simple tracheal* suction and reasonable respirator pressure adjustments; (b) pulmonary complications account for decreased distensibility of the lung so that higher respirator pressures are necessary to accomplish adequate tidal exchange (see Ventilatory Measurements—Tidal Volumes); (c) oxygen therapy is often necessary (see Oxygen Therapy), and (d) occasionally serious impairment of cardiac function is observed. In many instances satisfactory treatment is possible.

It should also be pointed out that upper lobe atelectasis may not produce serious impairment of pulmonary ventilation so that conservative treatment may be entirely adequate. In contrast *lower lobe atelectasis is usually due* to an obstructing mucous plug or inspissated mucopus in a primary bronchus. This condition requires immediate and energetic treatment because it almost always *results in* underventilation.

OXYGEN THERAPY

OXYGEN IS NEVER A SUBSTITUTE FOR PULMONARY VENTILATION

INDICATIONS FOR USE INCLUDE

- Supplementing oxygen partial pressure in the inspired air when adequate pulmonary ventilation cannot be achieved by any means.
- To compensate for abnormalities of ventilation of lung tissue due to atelectasis and pneumonitis.
- To provide higher diffusion pressure when—
  - An alveolar diffusion barrier is produced by pulmonary edema.
  - Circulatory failure may cause impaired pulmonary blood flow.
- To compensate for marked increase in oxygen utilization in some respirator patients with fever, infection, etc.

Oxygen must always be humidified before inhalation. If a normal airway is the route of administration a tent, plastic canopy, disposable mask, or funnel may be used. The tracheotomized patient requires special consideration to protect the tracheobronchial mucosa from extreme temperature changes and dry air/oxygen mixtures Several satisfactory nebulizing, fogging and mist producing devices are available. Wetting agents may promote dispersion and penetration of microscopic water droplets. An open delivery system with a close fitting delivery cup or chamber surrounding but not obstructing the tracheotomy tube is satisfactory. The total volume of the delivery system should be slightly larger than the tidal exchange. Concentrations of oxygen in excess of 50% are probably unnecessary.

METABOLIC DISTURBANCES IN ACUTE POLIOMYELITIS

ALTERATION OF WATER BALANCE: Dehydration, loss of skin turgor with dry mucous membranes, polycythemia, oliguria.

ELECTROLYTE DISTURBANCES: Evaluated by history and laboratory examinations *may show:*

- Elevated serum Na^+.
- Lowered serum K^+ and Cl^- (hypokalemic *alkalosis*).
- Chronic Na^+ depletion with low serum Na^+ and K^+.

OXYGEN UPTAKE DISTURBANCES. (See Oxygen Therapy.)

CO_2 ELIMINATION: Excessive—hypocapnia
Deficient—hypercapnia.

pH ADJUSTMENT: Acute patient *may have normal, acid or alkaline* arterial pH.

- pH is readily altered by hyperventilation or hypoventilation especially during artificial respiration.
- Slightly alkaline arterial pH (7.48-7.55) is well tolerated and may be a compensation of the acute disease state in the respiratory or severely ill patient.

In the acute phase of poliomyelitis the problems of water and electrolyte metabolism are in many respects similar to those of any acutely ill patient. Poor intake gradually leads to deficits of both water and electrolytes. Excessive loss of gastric or oral secretions (latter particularly important in bulbar patients) increases the magnitude of this deficit. In addition, high body temperature and respiratory disturbance *increase insensible water losses.* Clinical and laboratory evaluation should be combined for effective therapy. (See *Special Considerations in Water and Salt Loss in Poliomyelitis.*)

The *elimination of CO_2* may be normal or excessive when respiration is inadequate for O_2 intake. This is due to the more rapid rate of diffusion *of CO_2 (probably 25* times as rapid as O_2). Hypocapnia may therefore appear when ventilation is sufficient for large O_2 needs. CO_2 excretion is not a solely reliable guide to complete ventilatory adequacy in the acutely ill poliomyelitis patient.

TREATMENT OF METABOLIC DISTURBANCES IN ACUTE POLIOMYELITIS

FLUID DISTURBANCES: See Appendix on Correction and Maintenance of Salt and Water Needs.

ELECTROLYTE DISTURBANCES: See Appendix on Correction and Maintenance of Salt and Water Needs.

- Remember not only to give maintenance fluid and salt but also to replace antecedent deficits which may be LARGE.
- Follow urine Cl with Fantus test and Sp. Gr.

OXYGEN UPTAKE: See Oxygen Therapy.

- Set respirator to give amount of ventilation which achieves peak O_2 consumption. (Measured with ordinary BMR machine.) This is O_2 demand.
- Eliminate pneumonitis and atelectasis insofar as possible.

CO_2 ELIMINATION: Do not attempt to treat patient on the basis of CO_2 excretion. Oxygen consumption always takes priority.

pH ADJUSTMENT: Arterial blood.

- Alkaline pH, low CO_2 and low Cl^- and K^+: Treat as hypochloremic alkalosis due to cellular potassium deficiency.
- Acid pH, low CO_2—probably present only with acidosis of starvation, fever and partial renal failure. Force fluids and calories for good renal function, good circulation and adequate basal caloric intake.
- Acid pH and high CO_2—CO_2 retention due to extreme respiratory failure. Treat by improving ventilation.

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DIET AND TUBE FEEDING

CRITICAL PHASE

Maintain fluid and electrolyte balance. (See Special Considerations in Water and Salt Loss . . . and Method of Correction and Maintenance . . .)

Only calories are important in diet to provide minimum intake of 30 to 40 Cal/Kg. body weight as CHO.

POST-ACUTE PHASE

PATIENT ABLE TO SWALLOW

- Begin with regular soft diet and restrict whole milk to a pint per day in patients with extensive paralysis.
- Diet unrestricted unless obesity occurs.

PATIENT UNABLE TO SWALLOW

- Nothing by mouth should be attempted
- Tube feeding is started after height of acute phase has passed.
- Begin with glucose water by gravity naso-gastric drip in calculated amount. (See Method of Correction and Maintenance of Salt and Water Needs.)
- If no vomiting occurs (24 to 48 hours) add skim milk and strained orange juice for 24 hours. Example: Adult, 200 cc. of each alternating every 3 hours.
- Change milk to homogenized milk for the next 24 hours. Meet total water requirements.
- Then start formula calculated for adequate amounts of Calories, Protein, Carbohydrates, Fat and total fluid volume.

Protein needs
Under 1 year—3.5 gm./Kg.
1 to 3 years —2 gm./Kg.
Over 3 years—1 gm./Kg., but if tolerated 1½ to 2 gm./Kg

Fat—1 gm./Kg., often not well tolerated by early convalescent poliomyelitis patient.

Calories—40 Cal./Kg.

Carbohydrates—make up calories with carbohydrates.

EXAMPLE	*ANALYSIS*	
1 pint of milk		
75 gms. skim milk powder	Protein	59 gms.
2 eggs	Fat	30 gms.
1 egg white	CHO	174 gms.
100 gms Karo	Calories	1202
300 cc. apple juice	App. Vol.	1000 cc.

- First 24 hours give ½ calculated amount and make up fluid volume with water.
- Add water and electrolytes between feedings to meet total daily needs.

URINARY BLADDER RETENTION

ACUTE STAGE

OCCURENCE

- Less common in children and females, but frequent in adult males.
- Usually only occurs with bilateral lower extremity paralysis and abdominal muscle paralysis.

TREATMENT

- If catheterization becomes necessary, put in an indwelling catheter using the strictest of sterile techniques.
- Prevent dehydration—maintain dilute urine.
- Specific treatment of urinary tract infection depends upon identification of causative organism.
- Prophylactic use of sulfonamides or antibiotics is controversial.

REMOVAL

- Try removal as soon as acute stage is over.
- Urge patient to void at least every 3 to 4 hours after removing catheter (before distention of bladder occurs).
- If difficulties occur, use Prostigmine (0.5 mg. in adults) or Furmethide (3 mg. IM). Apply gentle manual pressure over bladder area Repeat in 20 minutes if there is no result.
- If patient is still unable to void, recatheterize and again attempt removal in two days.
- Determine if incomplete emptying (residual urine) is contributing to infection if such is present.

Especially in children conservative measures are often adequate so that catheterization is unnecessary. Frequent stimulation of voiding to prevent bladder distension and stimulant drugs are most important adjuncts.

Inability to remove catheter seldom occurs utilizing this procedure. It has been our experience, however, that if the catheter has been allowed to remain in place for five weeks, removal becomes difficult or impossible, and chronic bladder and renal infections are usual consequences.

NURSING CARE—ACUTE POLIOMYELITIS
ROUTINE ORDERS (S.W.P.R.C.)

- T.P.R. and B/P q 4 hours (unless otherwise ordered).
- TBC. Patch Test on admission (for children 6 months to 14 years).
- CBC on admission.
- Urinalysis on admission.
- Serology on admission.
- Weight and height on admission.
- No SEDATION OR ASPIRIN (unless ordered).
- Hot packs for pain (ordered by doctor). (See Symptomatic Management of Muscular Discomfort.)
- Catheterizations are done by nurse or doctor ONLY. Orderlies and practical nurses are not allowed to catheterize patients on Polio Service.
- Oxygen is NEVER given without adequate humidification. Use open system cold humidifier or fogging device. (See Oxygen Therapy.)
- Use ONLY RED SPECIAL EMERGENCY CIRCUIT OUTLETS for respiratory equipment. Do not plug any other equipment into these outlets.
- Charting must be accurate and detailed on acute patients Pulse and respirations should be counted for a full minute. Rectal temperatures are taken on all acute patients. Chart any progression and note time.
- Check Signs and Symptoms of Serious Polio and Signs and Symptoms of Respiratory Muscle Paralysis, Impairment of Swallowing, and Pulmonary Complications. Doctor should be notified at once of any marked progression, rise in blood pressure or pulse, or any untoward signs whatsoever.
- All acute patients in a respirator must be on the alarm system, even if there is a special nurse in the room.

SERIOUS POLIOMYELITIS

- See Immediate Measures in the Treatment of Impaired Swallowing.
- If patient has any mucous accumulation, Trendelenburg posi-

tion (ordered by physician). Position on side and abdomen, NOT ON BACK.

- Have aspirating equipment available at all times.
- Always check bronchoscopy and tracheotomy tables. Be sure they are complete and all equipment functioning. KNOW WHAT ENT DOCTOR IS ON CALL, and advise him of patient's condition.
- Always have a respirator checked and ready for use.
- See Signs and Symptoms of Serious Polio, Signs and Symptoms of Impairment of Swallowing, and Signs and Symptoms of Respiratory Muscle Paralysis.

NURSING CARE—HYGIENE

ORAL	• Toothbrush, toothpaste, emesis basin for routine mouth care. • Special mouth care as indicated, especially to patients not receiving oral feedings.
SKIN CARE	• Special emphasis to neck, back, and bony prominences.
BATH	• Complete daily bed bath. • Include range of motion to all extremities during bath. • Do not apply lotions and powders • Keep skin clean and dry at all times.
SCALP	• Massage daily to prevent pressure areas. • Shampoo once a week. Patients may and should be shampooed when confined to tank.
LINEN	• Change daily and P.R.N. Avoid wrinkles in sheets. • An extra draw sheet may be placed under patient to facilitate turning patient.
ELIMINATION	• Patients should be closely observed for bowel and bladder elimination. (See Management of Constipation and Impaction.)

Patients confined to the tank respirator demand and deserve excellent nursing care. Any nursing care procedure which should be performed for a critically ill bed patient should also be carried out for the tank bound patient by working through the portholes. Special attention must be given to the prevention of pressure areas especially of the neck and back. Frequent turning is one of the best preventive measures. Routine special back care is indicated. Neck care may be accomplished by soaping hand and massaging soap well into the neck. This serves to stimulate circulation and toughen the skin. This procedure may be done while patient is in the tank and without loss of pressure only when using the standard sponge rubber collar. A piece of foam rubber, not more than one-half inch thick wrapped in a soft diaper and placed around neck serves as an excellent neckpiece both for patient comfort and relief of pressure from lung collar.

SIGNIFICANT SOCIAL AND EMOTIONAL FACTORS IN POLIOMYELITIS

DIAGNOSIS OF POLIOMYELITIS CARRIES WITH IT A SUPER-EMOTIONAL CHARGE

- Unpredictability of outcome in the acute stage arouses anxiety in *the patient and patient's family.*
- Element of contagion causes—
  - Patient concern about other members of family.
  - Family concern about other members.
  - Reaction of neighborhood and community.
- Widespread dramatization of disease by press, radio, television—
  - Serves to arouse guilt in parents regarding observation of *publicized precautions.*
  - General idea of outcome—either permanent, severe crippling or death.
- Feeling of stigma arising from erroneous idea on the part of the public that occurrence of poliomyelitis is associated with inadequate personal and household hygiene, substandard living conditions

The Medical Social Service Worker can act as a bridge between the anxious family and the busy physician in establishing rapport and detecting social situations which may influence the patients' and families' acceptance of the medical program of management. Proper direction and utilization of social service activities by the physician will frequently help minimize and redirect the serious emotional and social consequences of *this disease.* Effective execution of home care planning and follow-up depends on early and consistent medical social service coordination.

SIGNIFICANT SOCIAL AND EMOTIONAL FACTORS IN POLIOMYELITIS

LONG TERM HOSPITALIZATION

- Frequent and considerable reassurance is required by the family during the isolation period.
- Small children frequently fear they have been deserted by family.
- Prolonged hospitalization places strain on family relationship.
- Sacrificing of privacy is difficult for some patients in the communal type of living.
- Financial hardships if family wage earner is the patient.
- Care of home and children if housewife is patient.
- Narrowing of interests with attention focused on physiological functioning results in an introverted patient
- Illness, resulting handicaps and long term hospitalization accentuates any pre-existing, faulty personality structures in patient and members of family

PHYSICAL IMPAIRMENT

- Inability of patient and/or members of family to accept the inevitability of some degree of physical handicap.
- Need for adjustment to new way of life imposed on patient and family.
  - Relatives frequently become over-protective toward patient.
  - Conflict in patient around dependency vs. independency.
- Special adaptation of home and physical environment—
  - Coordination of community resources.
  - Lack of resources.
- Change or modification of vocational goals.
- Attitude of employing groups toward handicapped individuals.

PSYCHOLOGICAL FACTORS

ACUTE

- Severe anxiety.
- Confusion, sometimes delirium.
- Stupor, sometimes coma.

EARLY CONVALESCENCE

- A shock-like reaction.
- Passivity.
- Regression, dependency, negativism.
- Guilt directed inwardly—diffuse self-blame in an attempt to find basis for his punishment.

BEHAVIOR RESIDUALS

- Guilt directed outwardly—patient tends to project his feelings of guilt by resentment and hostility to staff and/or family.
- Conflicting drives—dependency vs. independence.
- Emotional lability—tendency to over-react.
- Difficulty in concentrating—short attention span.
- Slowing down in ability to shift from one kind of mental activity to another.
- Stress reactions in solving unfamiliar problems.
- In residual paralysis, disturbance of the body-image and self-concept may be a troubling problem.

Intelligence tends to be somewhat higher than the general populat average. The mean verbal intelligence in an unselected series of 50 patie was 115, bright normal range. There are individual differences in this in the problems listed as characteristic of above stages. To meet a patie psychological problems, that patient must be studied as a total react personality.

There may be times when indicated medical procedures need to be justed to the psychological readiness of the patient. Grouping and movi of patients may be used advantageously to promote a better understa ing of their condition to motivate and to encourage more out-going intere

POST-ACUTE AND CONVALESCENT TREATMENT OF POLIOMYELITIS

IMPORTANT CONSIDERATIONS IN THE CONVALESCENT PHASE OF TREATMENT

The goal of convalescent care is to attain the most useful function of which the patient is capable.* This is reached by safe scheduling in which the physical activities required by the treatment program are balanced against the patient's tolerance. Practically, the attainment of this delicate balance throughout the recovery period is the largest problem in rehabilitation.

Positive prescription of treatment in convalescence is most difficult. Treatment in the acute phase is naturally suggested by the vivid alterations in body function which rapidly develop at the onset. In contrast, the partial or complete recovery which occurs subsequently may take months or even years. The gradual nature of recovery processes makes evaluation of the patient increasingly intricate and treatment needs less sharply defined. Complications also tend to be insidious and obscure.

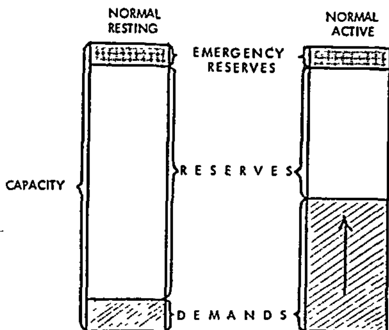
Any realistic program places increasing physical demands upon the patient. The muscular component is readily apparent, but simultaneously demands are placed upon other body functions which are not so clear but which may be of crucial significance. Recognition of these factors is implied in the caution of experienced clinicians to "avoid fatigue." Fatigue is an unreliable guide to proper programing since it reflects not only a physiological compromise but, in addition, a poorly understood and relatively inassessable psychological component.

For these reasons a theoretical framework has been devised to define the principles which appear to be important clinical precepts for the safe conduct of the severely involved and are useful in the optimum management of the majority of the patients.

Respirator patient experience has undoubtedly emphasized, in the extreme, the principles and the more reliable observations which bear upon this most complicated situation.

* Useful is not necessarily the most active function possible

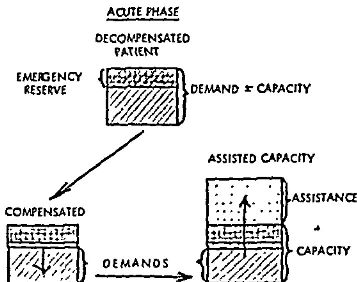
THEORETICAL COMPONENTS OF BODY FUNCTION IN HEALTH



The bar graphs crudely illustrate the dynamic situation in which CAPACITY FOR PHYSIOLOGIC WORK is the maximum ability of the person to perform a particular function, e.g., respiration, circulation, muscular contraction, etc. DEMAND represents that proportion of the capacity which is utilized in the energy expenditure required by the particular activity.

As a primary hypothesis it seems likely that an individual's capacity for physiological work of a particular kind normally exceeds any demands which are put upon it. In the case of breathing, quiet respirations involve minimal and most efficient energy expenditure for the work accomplished. The amount of work and the cost in energy can increase tremendously upon demand. In an emergency energy output can even temporarily exceed oxygen supply by virtue of anaerobic metabolism. The range through which increasing work output extends can be considered the reserve for meeting ordinary demands or sudden extreme needs occasioned by unusual activity, stress and disease.

THEORETICAL COMPONENTS OF BODY FUNCTION IN DISEASE



R,: REDUCED DEMAND PLUS ASSISTANCE TO REDUCED CAPACITY!

The insult of a disease such as poliomyelitis reduces many of the body's capacities, e g , respiratory muscle paralysis decreases breathing capacity. When the reduction in capacity is severe, the demands of basal activity may exceed the maximum effort which is possible. In the face of unavoidable demands upon inadequate capacities immediate correction must be made to prevent irreversible damage and death. There are three measures which are generally employed· (1) Reduce demand to the most basal state which can be obtained; (2) supplement or substitute for inadequate functions where possible, e g , artificial respiration, (3) attempt to correct unsuitable or harmful body responses, e.g., severe hypertension, hypotension, etc. These principles are easily demonstrated in the treatment of severe respiratory impairment and other vital neuromuscular involvement. The decreased capacity of body functions such as circulation, metabolism and even psychologic activity may be much less obvious.

To some extent such considerations apply to most bodily activity in greater or lesser degrees depending upon the constitution of the person and the magnitude of the insult.

The bar graphs illustrate the role of reduced demand and assistance or substitution in the preservation of life sustaining capacity

CAUSES OF MUSCULAR WEAKNESS IN POLIOMYELITIS

DIRECT VIRAL INVASION

MOTOR NERVE CELL

- Permanent destruction of the motor nerve cell with atrophy of denervated muscle fibers.
- Reversible changes with temporarily impaired nerve cell function and altered muscle contraction.

INTERNUNCIAL NERVE CELLS OF THE SPINAL CORD

- This may disrupt all but two neurone spinal reflex arcs and interfere with those descending tracts which end around internuncials as well as cross connections of segmental reflex arcs.
- *Permanent destruction or reversible damage with recovery.*

SUPRA-SEGMENTAL NEURONES

- Generalized hypotonia of central origin as seen in encephalitic forms.

INDIRECT CAUSES

- Reflex inhibition of muscular activity due to pain.
- Nutritional and metabolic disturbances leading to impaired muscle cell function, e.g., alkalosis, hypokalemia, etc.
- Potentiation of muscular weakness by fatigue and overstretching.
- Disuse atrophy.

The most frequent and important cause of persistent muscular weakness is the invasion of the motor nerve cell by the virus agent. Clinical evaluation of this spinal cord process is obviously inexact. When nerve cell destruction is extensive enough to eliminate the majority of the motor units comprising a muscle, flaccid paralysis with absent tendon reflexes is observed. Apparently a considerable number of motor units can be inactivated before clinical evidence of "weakness" appears. Various grades of "weakness" cannot be directly related to the extent of motor nerve cell destruction. Treatment is nonetheless based upon the assumption that recovery of the cells can occur. Time alone decides whether significant destruction has occurred since 50-75% of the eventual recovery of muscle

power will occur in three to six months and maximum recovery is generally seen within 18 months.

The other causes of weakness probably contribute in various degrees to the acute symptoms and account in part for some of the remarkable recoveries which clearly cannot be a result of reconstitution of the motor nerve cell population.

BODY POSITIONING OF THE POLIOMYELITIS PATIENT

OBJECTIVES

- Maintain normal skeletal alignment.
- Prevent deformities.
- Protect weak muscles from continuous stretching.
- Relieve pain and restlessness.

ACUTE STAGE

- Frequent and judicious change from back to side and abdomen (if tolerated) with use of pillows and rolls as needed to place shortened painful muscles in a rest position.
- Maintain body alignment within the limits of comfort.

POST-ACUTE STAGE

- Gradual reduction in amount of pillows and rolls to those needed for maintaining good body alignment.
- Support weak muscles.
    - Hand rolls
    - Foot board, shoes on board.
    - Knee roll.
- Counteract muscle imbalance and habitual positioning.
    - Change rest position of all joints at periodic intervals.
    - Range of motion

The nursing care of patients with poliomyelitis is identical to the care of any acutely ill patient. Attention to pressure areas, proper positioning, and range of motion are of primary importance in preventing decubiti, stasis, and deformity. Patients are turned and positions changed at least every two hours. Hands should be kept in a functional position, feet positioned to prevent foot drop, and lower extremities positioned to prevent outward rotation. Knee and ankle rolls should be of proper size—avoid the use of large soft pillows.

Any one continuous position will produce detrimental effects on the further rehabilitation of the patient. Positioning and range of motion must accompany each other for good care.

RANGE OF MOTION

PURPOSE

- To minimize fibrosis and contracture in muscles, tendons, fascia, and joints which occur from immobilization and habitual position.
- To maintain and increase the present range of motion.

USE

- When active motion of all joints cannot be performed by the patient, as in muscle paralysis or unconsciousness.

PROCEDURE

- Support the part firmly.
- Move the part just short of the point of pain through its full range if possible.
- Repeat each motion three to five times at least once daily.

Range of motion need not be done as a complete and separate procedure once the routine is learned It can be accomplished on an extremity or joint at a time during routine care such as the bath, taking of blood pressure and changing positions. In acute polio the muscle bellies are sore and tender. For the patient's comfort, he should be handled and moved at joints and bony prominences with the flat of the hand. See Joint Range of Motion for specific motions

EVALUATION OF INDIVIDUAL MUSCLE STRENGTH BY THE USE OF MUSCLE ACTION, PALPATION, GRAVITY AND MANUAL RESISTANCE

USEFUL FOR

- Diagnosis: Presence, pattern and extent of muscle weakness.
- Prognosis: Area of involvement.
  Rate of progression of weakness.
  Magnitude of loss of muscle power.
  Rate and extent of recovery.
- Treatment and its evaluation in:
  Muscle re-education
  Assistive supports and splints.
  Permitted functional activity.
  Reconstructive surgery.

GRADING (Lovett system—the basis for most present day grading.)

100% Normal	Complete range of motion against gravity with full resistance. (A normal muscle, regardless of age, build, occupation, etc. has a resilient (springy) feeling when resistance is applied.)
75% Good	Complete range of motion against gravity with moderate resistance. (A GOOD muscle will play out when resistance is applied.)
50% Fair	Complete range of motion against gravity.
	Complete range of motion with gravity eliminated.
10% Trace	No motion of the part, but contraction of the muscle or tendon is felt.
0% Zero	No motion or contraction present.

Physicians will find it valuable to be familiar with general group muscle testing for diagnosis and planning the treatment program. (See General Evaluation of Muscle Strength), but usually rely upon the skill of the physical therapist for a detailed muscle examination. In the diagnostic and

acute stages of poliomyelitis a quick general evaluation of muscle strength is sufficient, so that the patient is not unnecessarily exhausted. Poliomyelitis, especially in the stage of progression, is characterized by asymmetrical weakness involving muscle groups around the same spinal segment.

After the patient has been afebrile for 48 hours a detailed muscle test is in order. It is recognized that muscles perform in groups and that their actions are overlapping. Nevertheless, no two muscles have exactly the same action and no motion can be performed normally without all of its muscular components. With good knowledge of muscle function, careful positioning and observation, the strength of each muscle can be differentiated and a treatment program instituted

PROCEDURES USED TO INCREASE MUSCLE STRENGTH AND COORDINATION

MAXIMUM RECOVERY OF BALANCED MUSCULAR ACTIVITY REQUIRES CONTINUOUS ATTENTION

INITIALLY

Protect and Coordinate

Protect Weak Muscles by Avoiding Continuous or Purposeless Activity

- Bed rest.
- Support weak muscles.
- Limit physical activity.

Utilize Splinting Which Assists Function and Prevents Substitution. See Assistive and Supportive Apparatus.

Institute Muscle Re-education

- Retrain "proprioceptive mechanism"—awareness of the dynamic position of muscles, joints and entire body members.
- Increase muscle power.
- Achieve and strengthen coordinate patterns of motion.

Strengthen

Prevent Substitute Action of Strong Muscles for Weak Ones—Leading to Imbalance and Deformity.

Do Not Overuse Weakened Muscles (overuse produces progressive incoordination—development of *faulty motion patterns and loss of power.*)

LATER (3 to 9 months) SELECTIVELY STRENGTHEN APPROPRIATE MUSCLES BY HYPERTROPHY TO

- Compensate for muscular imbalance.
- Obtain maximum strength for useful work or appropriate substitute activities
- Obtain maximum endurance in function.

As pain and soreness subside passive range of motion is established. Then a program of re-education of the muscular system is started. This consists of progressively increasing the work of the muscle by manual assistance,

changes in the amount of friction upon the part being moved, increasing the work of the individual muscle against the effect of gravity and resistance. At no time is the patient allowed to produce jerky motions or utilize other than the desired muscle or muscles. These principles are accomplished most effectively by the physical therapist Careful employment of auxiliary aids such as hydrotherapy, sling suspension and counterbalancing weights may assist the physical therapist in attaining the desired end result.

EARLY

- Teach normal patterns and actions, e.g., use crutches *to maintain* normal relationship of parts in the walking pattern to stimulate further recovery and balanced action.
- Work below maximum tolerance of the patient.

LATER (6 to 12 months) OVERDEVELOP RESIDUAL ABILITIES TO SUBSTITUTE FOR LOST MOTIONS—INCREASE WORK DEMANDS

- Increase proprioceptive senses through repetitive practice.
- Hypertrophy remaining useful muscle fibers by high resistive exercises.
- Develop skill in substitute actions, e.g., moving from wheel chair to bed using arms, tying shoes with one hand.
- Utilize assistive devices where needed to increase function and endurance.
- Develop endurance by repetitive highly resistive exercises and skills to the point beyond which performance suffers.
- Utilize surgical procedures to restore motion, stabilize, and eliminate appliances.

Useful functional *achievement is the goal of all rehabilitation programs.* The patient should be tested to determine his independent ability to perform ordinary daily acts such as dressing, brushing teeth, eating, walking, climbing stairs, etc. and a program for attainment should be outlined. Goals are based on the muscular capabilities, the physiological capacity, the practical need for the activity and the patient's desire.

Retraining and substitution of residual abilities is similar to the program of activity analysis and the development of skill and endurance used in the training program for the superior athlete.

ORTHOPEDIC SURGERY
GENERAL CONSIDERATIONS IN POLIOMYELITIS

PREVENTION IS MORE DESIRABLE THAN CORRECTION

AIMS

- Prevent deformities of bony structures—of primary importance for the growing child.
- Restore or assist useful function.
- Eliminate appliances and apparatus while maintaining function.
- Correct deformities.

EMPLOY EXTREMELY CAREFUL EVALUATION OF THE PATIENT IN ORDER TO INSURE THE EFFECTIVENESS OF SURGICAL PROCEDURES

- Effectiveness of surgical procedures depends as much upon the functional capacity to take advantage of the result as upon the perfection of the operation, e.g., a probably successful opponens transplant may be contraindicated in the absence of extensor digitorum communis function.
- The specific procedure used and the end result obtained depend upon patient cooperation and the adequacy of follow-up care.
- Utilize accurate estimations of bone age in planning surgical procedures.
- Stabilization and fusion operations are performed to assist function, increase stability, correct associated deformities or eliminate the need for appliances.
- Tendon transplants are used to substitute for a lost function or to redirect a deforming force.
- Transplants for motors should use muscle which has at least 70% of normal strength.
- Proper combinations of stabilization and transplants may achieve better function than either alone.

These factors are presented to aid the physician in understanding the role of orthopedic surgery and to facilitate its effective employment at the most suitable time. The Orthopedist must see the patient early and follow

MANAGEMENT OF NEPHROLITHIASIS

PREDISPOSING FACTORS

- Long standing immobilization with demineralization and hypercalcuria, infection of the urinary tract, oliguria, urinary stasis, and constitutional factors.

PREVENTIVE MEASURES (see Urinary Bladder Retention and Treatment of Metabolic Problems in Post-Acute Poliomyelitis)

- Maintain adequate urine volume with large fluid intake to obtain urine sp. g. of 1.010 to 1.020.
- Evaluate for the presence of stones with serial abdominal plane film radiography for early treatment.
- Avoid high vitamin D intake.
- Utilize serial urinalysis and urine culture to permit prompt, adequate and specific anti-bacterial therapy.
- Mobilize the patient as soon as practical: use early physical therapy, see that there are frequent changes of body position, attempt early skeletal weight bearing using the standing bed.
- *Use periodic renal functional studies with history of infection* and evidence for hypertensive cardiovascular renal disease.

COMPLICATIONS

- Uretero-pelvic and ureteral obstruction—signaled by fever, polymorphonuclear *leucoytosis,* dull flank *pain and/or intermittent* colic, microscopic hematuria and pyuria which may be absent at the onset.
- ACUTE renal shutdown.

TREATMENT

- Use IV pyelography to determine functional status of the kidney and establish site of obstruction if such exists.
- Instrumentation is necessary to dislodge stone or remove it if possible.
- Ureteral catheterization *to by-pass stone and promote pelvic* drainage and irrigation.
- Surgical intervention may be necessary to preserve kidney if instrumentation fails and renal shutdown persists.
- ALWAYS retrench respiratory schedule in respirator patients
- Use whole blood transfusions *if hemoglobin is low.*

Preventive measures may be inadequate and impossible to attain. Treatment for secondary infection must be prompt to avoid chronic renal inflammatory disease and subsequent impairment in renal function. The primary hazard of renal shutdown must be corrected if possible. There is little doubt that these intercurrent complications appear to interfere severely with the respiratory patient's rehabilitation program and retrenchment is essential.

BEGINNING WEANING FROM RESPIRATORY ASSISTANCE OF THE IMMEDIATE POST-ACUTE PATIENT

ESTABLISH CONFIDENCE IN THE PATIENT AND FAMILY DURING THE ACUTE STAGE

- Absolute familiarity with equipment by the entire staff to avoid apprehension due to "accidents."
- Avoid having patient or family dictating treatment.

PRELIMINARY POST-ACUTE EVALUATION

- Tidal volumes in the tank respirator.
- Vital capacity if possible.
- Observe breathing muscles.
- ECG
- Frequent blood pressure and pulse.
- CBC
- Muscle test.

TREATMENT FOR THE FIRST TWO WEEKS

- Establish hospital routine and eliminate special privileges for patient and family.
- Discontinue oxygen therapy.
- Reset pressure and/or rate of tank respirator to the lowered needs of convalescence to avoid hyperventilation
- Set and maintain daily breathing schedule
  - Introduce cuirass respirator twice daily, beginning with fifteen minute periods and increasing to one-half to one hour
  - Breathing alone three times a day IF vital capacity is more than one-half of tidal volume. (If this is the case only three to five minutes should be allowed. If vital capacity is more, periods may be up to, but not exceed one-half hour.)
- Bath during a.m. and physical therapy during p m. cuirass times.
- Remove urethral catheter.
- Remove tracheotomy tube.

After becoming accustomed to the cuirass respirator and short periods [illegible] there is no danger of the patient becoming addicted to [illegible]

METHODS OF EVALUATING THE RESPIRATORY PATIENT FOR THE PROGRESSIVE WEANING AND REHABILITATION PROGRAM

RE-EVALUATION OF THE PHYSIOLOGICAL RESERVES WITH REPETITION AT LEAST MONTHLY THEREAFTER

FACTORS USED IN DETERMINING PROGRAM

- **Vital capacity value:** Its magnitude; relation to tidal volume needed for breathing and breathing muscles used, rate of increase, appearance of a decrease, appearance of plateaus or sudden changes; variation between horizontal and sitting values (with and without abdominal support).
- **Maximum breathing capacity values:** Which indicate increase, decrease and dissociation from vital capacity values.
- **Tidal volume:** In tank and cuirass respirator to determine adequacy of ventilation in different devices and for avoidance of hyperventilation.
- **Fluoroscopic observation:** Use of breathing muscles, pulmonary aeration, pulmonary complications and cardiac silhouette (if patient can breathe alone for 5 minutes).
- **CBC:** For appearance of anemia or polycythemia due to hypoxia.
- **ECG:** Heart rate, rhythm disturbances (especially nodal rhythm, intermittent nodal rhythm or escaped beats), P-R distance, width of P and QRS, Q-T time, frontal and spacial projection of QRS and T-vector, presence or absence of RS-T deviation, evidence of stress.
- **Blood pressure and pulse:** (Taken for stability of 2 day series) for pattern of mean values, evidence of hypertension, intolerance to upright position and physical activity.
- **Blood chemistries and urinalysis:** For evaluation of renal function.
- **Complications of any variety influence capacity for unassisted breathing.**

There is no substitute for clinical judgment for optimum care. Observation of the patient's general appearance, appetite, attitudes, cooperation, signs of fatigue, and needs for rest should be made. All of the above with a

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consideration of the patient's feelings, staff observation of his attitudes and objective tests should be used in determining the pacing of the patient's entire program.

It is recognized that even with these guides the patient may be advanced too rapidly. Breathing aid should be increased and/or activity decreased until the patient becomes stable in his various responses. Then the program should be gradually progressed again.

Intercurrent complications—infections, etc—always require retrenching in the direction of increased respiratory assistance.

PROGRESSIVE REHABILITATION OF THE CONVALESCENT RESPIRATOR PATIENT

- A schedule is unchanged for at least one to two weeks so that adequate observation can be made. Patient and nursing staff should not alter the schedule.
- Gradual weaning from the tank respirator during the day depends upon early progressive use of less effective breathing aids.
    - Introduce the rocking bed.
    - Increase the cuirass respirator time.
    - Increase breathing alone time IF breathing muscles and physiological reserves permit.
- Gradually increase the variety and extent of activity using the cuirass respirator during such activities. (Physical and Occupational Therapy Progression in Respiratory Polio.)
- Evaluate the patient for sitting and performing functional activities without using breathing aids. Start with the reclining chair and evaluate responses to the upright position. Gradually assume full upright position.
- Change to cuirass or rocking bed at night if possible, starting with 1 night a week, if tolerated, increase to 2, etc ...
- If elimination of respiratory aid at night is to be considered, it should be done 1 night a week and then 2 and so on ...
- Carefully consider the physiological reserves and the practicality of walking before attempting such physical effort Walking should not be considered if the vital capacity is below 800 cc. in an adult
- Use breathing aid at night and/or for rest periods in order to conserve energy for increased activity during the day.
- [illegible]

This is a continuous slow process over weeks and months, each change followed by a period of observation. Only one variable is changed at a time so that the breathing schedule is increased while activity is held constant or vice versa Sacrifice weaning speed if necessary to allow neuromuscular rehabilitation to proceed concomitantly. It is obviously more desirable to have a well adjusted, functional, clear thinking individual using breathing help than to have a chronically underventilated, tired, stressed and irritable patient who breathes unaided.

PHYSICAL AND OCCUPATIONAL THERAPY PROGRESSION IN RESPIRATORY POLIOMYELITIS

PHYSICAL ACTIVITY CATEGORIES

O NO TREATMENT

- No physical or occupational therapy procedures except positioning to maintain good body alignment and comfort.

I. MUSCLE EVALUATION AND JOINT MOTION: To evaluate neuromuscular status, relieve muscle pain, and maintain joint motion.

- Initiated 48 hours after febrile stage.
- All motions (with the exception of shoulders) can be carried out in tank respirator (see Range of Motion).
- Usually between the 5th and 15th day from onset the patient can tolerate the cuirass respirator for periods sufficiently long enough to carry out all procedures adequately.

II. STRETCHING, MUSCLE REEDUCATION AND OCCUPATIONAL THERAPY IN BED: To increase range of motion and re-establish coordinated neuromuscular patterns of motion.

- All procedures may be done in the cuirass respirator from the back-lying position.
- For posterior muscle groups the therapist must support the weight of the part and use gravity assisting exercises.

III. HYDROTHERAPY OR STANDING BED: Hydrotherapy utilized to relieve muscle pain and tightness and for muscle reeducation. Standing bed to achieve weight bearing and promote circulatory adjustment to the upright position.

- Transportation of patient may require portable motor for cuirass respirator.
- Hydrotherapy and standing bed accomplished using cuirass as ordered.
- Hydrotherapy and standing bed may be done on alternate days if both are indicated.
- Utilize abdominal support and leg binding to minimize venous pooling
- Exercise procedures done at another period during the day

The standing bed is utilized as a convenient and practical method of gaining the necessary circulatory adjustment to the vertical position and at the same time to start weight bearing. Patients are started at 30° and over a period of days and weeks the angle and the time are increased. Frequent pulse rate and blood pressure determinations are taken before, during and following the procedure and the patient is observed for color, presence of perspiration, and general feeling of well being as aids in judging the rate of progression.

PHYSICAL AND OCCUPATIONAL THERAPY PROGRESSION IN RESPIRATORY POLIOMYELITIS

PHYSICAL ACTIVITY CATEGORIES

IV. **RECLINING CHAIR, HYDROTHERAPY, STANDING BED, OCCUPATIONAL THERAPY IN SHOP:** To prepare for function and coordination of breathing and balance with activity.
- Patients are started in a reclining chair (lounge type with undercarriage) and gradually increased in time and angle towards vertical.
- Beginning muscle reeducation in overhead arm slings—activities of a light nature.
- Procedures are spread over the day either using the cuirass or breathing alone depending upon medical order.

V. **SITTING STRAIGHT:** To gain function in the upright position probably using slings and adaptive equipment.
- Utilize full reclining back wheel chair for short periods.
- Change to conventional straight back wheel chair if possible and practical for the patient.
- If it is decided that patient may now sit without breathing aid, he should be dropped back to category IV and progressed to his tolerance.

VI. **NO CARDIO-RESPIRATORY PROBLEM**
- Patient is managed as uncomplicated poliomyelitis.

The respiratory patient needs and can receive all the procedures that are ordinarily given in uncomplicated poliomyelitis, but can accept them only if given over an extended convalescent period. These categories are utilized as a general guide to increasing energy demands on the patient. They are arrived at by evaluation and joint staff conference with the physiatrist and orthopedist prescribing the specific procedures which are allowed by the tolerance categories Infections always require retrenchment, the patient is put back to activity categories of O or I followed by gradual resumption of activity.

FUNCTIONAL ACTIVITIES FOR THE SEVERELY INVOLVED RESPIRATOR PATIENT

OBJECTIVES

- Function in the upright position.
- Promotion of outgoing interest and self confidence.
- Development of occupational and social usefulness.

METHODS: Integrate energy consuming activities gradually according to the patient's tolerance and ability (see Methods of Evaluating the Respiratory Patient . . . and Physical and Occupational Therapy Progression).

- Increase sitting angle and sitting tolerance.
- Increase neck and trunk balance.
- Coordinate breathing and talking in the upright position.
- Utilize activities requiring small energy expenditure–reading, needlework, etc.

PRIMARY FUNCTIONAL GOALS: Self help and self care are stressed with manual activities used to develop the required motions. Such goals are relatively low in energy expenditure and of high functional importance.

- Reading (turning pages).
- Communication (write, type, talk on phone).
- Self feeding.

SECONDARY FUNCTIONAL GOALS: Increase scope of activities in ratio to physical and mental ability.

- Personal care (make-up, shave, brush teeth, comb hair).
- Sedentary occupation (household duties, office work).
- Dressing, propelling wheel chair.
- Transferring (to bed, wheel chair, toilet, shower, car, etc.).
- Walking, climbing stairs, etc

In respirator patients only limited activity can be achieved due to the markedly reduced physiological and muscular capacities for work. Goals of attainment should be set which will accomplish the most useful function with the least expenditure of energy. Full exploration of the possible scope of activity is necessary as well as periodic evaluation and the use of self

help devices if a much greater and more desirable end result is attained. Accomplishments are greater than would be suspected possible from the extent of paralysis. Children are able to complete their education, mothers can supervise and help in the household and often supplement the income. Many patients have become partially or totally financially independent through occupations such as merchandising, selling services, teaching in all of its aspects, abstracting, translating, providing answering services, managing businesses, and acting as technical consultants.

EARLY EVIDENCE OF INJUDICIOUS RESPIRATORY PROGRAMING EXCESSIVE ACTIVITY

EMOTIONAL LABILITY: Disinterest–addiction to respiratory aids, to the immediate environment and personnel–lack of motivation or unreasonable drive.

SPONTANEOUS BREATHING IS PROGRESSIVELY DYSPNEIC AND RAPID

ALTERATION OF VITAL SIGNS

- **Pulmonary compartments:**
  - Vital capacity—arrest of progressive increase (utilize average of several measurements).
  - MBC—relatively low.
- **Circulatory measurements:**
  - Increase in average pulse rate.
  - Instability of 48 hour series of pulse rate.
  - Slight increase in average diastolic pressure of 48 hour series.
  - Serial and progressive ECG evidence of shortened P-R time *and prolonged Q-T time.*

BLOOD CHEMISTRIES: Progressive elevation of serum Ca^{++} and fall of serum K^{+} – Na^{+} high normal to elevated.

BLOOD ELEMENTS: Increasing or decreasing Hgb.

URINE: Decreasing Sp Gr—increasing volume.

Determination of stress which ultimately produces serious physiological decompensation is an important aspect of the convalescent care of severe paralytic poliomyelitis. The ease with which limited body reserve is exceeded appears to depend upon complex factors such as, (a) residual circulatory and respiratory insufficiency; (b) the metabolic and nutritional status of the patient, (c) the speed and manner of resumption of physical activity, (d) severity of muscle paralysis, and (e) individual constitutional characteristics

Separate identification of the contributing factors is not often possible or so important as the elimination of injudicious respiratory scheduling and excessive activity. The detection of excessive activity may be simplified by the comparison of repeated surveys of the type indicated.

SIGNS AND SYMPTOMS OF SEVERE STRESS

- **Irritability—drowsiness—fatigue—lack of cooperation.**
- **Increased need and desire for breathing assistance—dyspnea—"all or none" effort.**
- **Increase in body weight—edema—puffy facies**
- **Hirsutism—seborrhea—acne.**
- **Nutritional disturbances—gastrointestinal disturbances with distension, vomiting, bleeding.**
- **Dehydration—temperature elevation.**
- **Decreased vital capacity.**
- **Progressive alteration of vital signs.**
    - Marked increase in pulse rate and instability.
    - Systolic and diastolic hypertension.
    - ECG evidence of marked decrease in P-R time and prolongation of Q-T, QRS vector alterations with altered T waves and Q-T-T separation—high peaked P waves.
- **Blood chemistries—Na^+ retention and K^+ depletion — elevated Ca^{++} — increased B.U.N.**
- **Urine—elevated 17-ketosteroids—failure of renal concentration** *and/or oliguria*

Since severe stress involves many body functions there is no single reliable indicator. Early detection depends upon single observation of parallel changes in several body functions such as mental condition, declining vital capacity, circulatory status, elevated blood pressure, altered serum electrolytes, etc. Most frequently, the trend of a series of relatively simple [illegible] forestalls improper progression of respiratory and physical [illegible] versus inactivity may [illegible] ion, such as markedly elevated blood pressure, which may be irreversible. There is increasing evidence that the poliomyelitis patient may achieve more useful activity and a better respiratory prognosis with fewer intercurrent metabolic and circulatory complications if such a philosophy of treatment is utilized. It is a cautious program of evaluation, care and rehabilitation which initially takes more time and effort

REMOVAL OF THE TRACHEOTOMY TUBE

PREREQUISITES

- Ability to swallow fluids and solids without aspiration.
- Absence of pulmonary pathology by X-ray.
- Demonstration of effective swallowing with lipiodol by fluoroscopy.

DISADVANTAGES OF RETAINING TUBE UNNECESSARILY

- Stimulation of excessive secretion so long as foreign body (tube) is in the trachea. This necessitates more nursing care and handicaps accurate evaluation of the breathing reserve.
- Slower progress in weaning from respiratory aid is observed.
- Addiction to unnatural airway occurs especially in children.

PROCEDURE

- If large tube was used, decrease size and length over a period of several days.
- Close tube during the day for several periods as long as tolerated. Open for suction only as needed.
- Gradually close for 24 hour periods, only opening for suctioning
- After two or three days remove the tube.
- Use artificial coughing devices and coughing maneuvers in the tank respirator to prevent accumulation of secretions.
- Steam inhalations for two or three days liquefies secretions.
- If failure occurs (rarely) replace the tube.
- Before attempting removal in one to two weeks obtain tracheal culture and sensitivity tests and place patient on prophylactic antibiotics.

As soon as prerequisites are present, removal procedures should be started. Remove tracheotomy tube even if some suctioning is necessary, since mucus will be present as long as the tube is in place

NURSING CARE—POST-ACUTE RESPIRATORY POLIOMYELITIS ROUTINE ORDERS (S.W.P.R.C.)

- When reinstituting oral feedings in the patient recovering from impairment of swallowing, a nurse should always be in attendance.
- Breathing schedules are posted on the bulletin board, in the patient's room and in the Kardex. Schedules are ordered by the doctor. Patients are to be kept on schedules as much as possible and no changes are made unless approved by the doctor.

EXAMPLE OF BREATHING SCHEDULE

	C. F.	3/13/53
9 *to* 12		Alone
12 *to* 5		Monaghan
5 *to* 9		Alone
5 P.M. *to* 9 A.M.		Monaghan

- There are activity schedules and therapeutic appliance schedules on bulletin boards in patients' rooms
- RESPIRATORY STUDY CHARTS: See example on page 92. These charts are run for 48 hours. They are ordered by the doctor who fills out the schedule. The charts are started at 6 A.M. and completed at 6 A.M., 48 hours later. The patient's pulse, respirations and blood pressure are taken BEFORE he is changed to another type of breathing aid and before he starts breathing alone. The respiratory rate of mechanical breathing equipment should be counted and recorded in "Respirations" column.
- If a patient spends all day in the same type of breathing aid or if he is completely weaned, the vital signs should be taken every 4 hours, 6 A.M. to 10 P.M. for 48 hours. If the patient spends more than 4 hours in one type of respiratory aid, the vital signs should be taken at the end of 4 hours.

Example:

8 to 2	Monaghan
2 to 5	Rocking Bed
5 to 9	Monaghan
9 P.M. to 8 A.M.	Tank

- The blood pressure, pulse, and respirations should be taken at 7:55 A.M. before taking patient out of tank; at 12 noon because he has been in the same type of aid for 4 hours; at 1:55 before taking patient off rocking bed, at 8:55 before taking patient out of Monaghan
- Medications containing iron are to be given between meals and are never given with milk
- Enemas are given PRN. An oil retention enema may be given if necessary. See Management of Constipation and Impaction.
- Respiratory patients MUST be able to breathe 15 to 30 minutes alone before they are taken to the bathtub. Check with nurse in charge before taking such a patient for the first time.
- Patients may leave the hospital with doctor's permission for specified times.

RESPIRATORY STUDY SHEET 4

NAME W.A. - W. M. 29 Yrs. Wt. 136, Ht. 74" DATE 8-11-54

Order:
9 - 11:30 Cuirass
11:30 - 1:30 Rocking Bed
1:30 - 4 Cuirass
4 - 6 Rocking Bed
6 - 8:30 Cuirass
8:30 p.m. - 9 a.m. Tank Resp.
R.R.J M. D.

Date	Time	Kind of breathing (RB, M,T, Alone)	Pulse	Respiration rate	Blood pressure
8-11-54	6 A.M.	TANK	80	T (20)	140/?
	8:				
	9:	TANK → CUIRASS	100	T (20)	155/?
	10:				
	11:30	CUIRASS → ROCKING BED	78	C (20)	175/125
	12:				
	1:30 P.M.	ROCKING BED → CUIRASS	102	R.B. (18)	175/130
	2:				
	3:				
	4:	CUIRASS → ROCKING BED	84	C (20)	150/110
	5:				
	6:	ROCKING BED → CUIRASS	90	R.B. (18)	140/105
	7:				
	8:30	CUIRASS → TANK	84	T (20)	130/110
	9:				
	10:	TANK	86	T (20)	140/?
	11 & 12				
	1 & 2				
	3 & 4				
	5 & 6				

PATIENT BREATH ALONE FOR BR PERIOD

Record blood pressure, pulse, respiration five minutes before changing from one kind of breathing to another. If patient is continuously in one kind of breathing aid, take values again two hours and four hours after starting. Don't stop tank or rocking bed when taking values.

MANAGEMENT OF CONSTIPATION AND IMPACTION

PREVENTION IS BEST—NORMAL FLUID INTAKE AND DIET ARE IMPORTANT

ENCOURAGE ELIMINATION AT REGULAR INTERVALS

- Avoid use of cathartics.
- Give soap suds enema every other day if necessary for proper elimination
- Give oil retention enema if S.S.E. is not effectual.
- Manually break up and remove fecal impactions with well lubricated gloved index finger.
- Do Not Exhaust Patient
- Feces formation is minimal during parenteral alimentation

CAUSES

- Dehydration—minimal bulk in diet.
- Absence of effective abdominal muscle contraction with increase in intra-abdominal pressure
- Distention of bowel and disturbances in motility.

Never give more than two successive enemas especially to the respiratory patient. If after two enemas good results have not been obtained, the patient should be allowed to rest a few hours Then he should be given an oil retention enema and placed in slight Trendelenburg position for one half hour, which aids the patient in retaining the oil Follow with a soap suds enema. Patients with severe constipation may benefit by an oil retention enema the night preceding soap suds enema.

Patients with fecal impactions may complain of abdominal discomfort, nausea and vomiting Objectively, impaction can be noted by abdominal distension, by palpation of the abdomen, or by difficulty in inserting a rectal thermometer or rectal tube.

If the impaction is high, it may be necessary to give an oil retention enema followed by soap suds enema until the bowel is cleaned out. The danger of exhausting the patient is always present and these treatments should be spaced over a period of hours or days depending on the number of treatments necessary and the patient's condition. The respiratory patient is especially distressed when suffering from a fecal impaction and usually requires maximum breathing aid if prolonged treatment is necessary.

HOME CARE PLANNING FOR THE RESPIRATORY PATIENT

PRELIMINARY

EARLY AND PROGRESSIVE PLANNING IS ESSENTIAL

- Periodic evaluation and programing by the entire staff.
- Discussion of the program and aims with the patient and family.

PSYCHOLOGICAL AND SOCIAL ADJUSTMENT

- Gradual adjustment of the patient and family to the practical significance of his medical, social, and psychological prognosis (including the fact that the patient may not make full recovery).
- Exposure to group of similarly impaired patients, and especially to those who return from home for check-ups.
- Evaluation of patient and family.
- Encourage participation in outside social activities (with doctors and nurses in attendance).
- Gradual introduction of the family to the complications of care.
  - Attendance at above social activities with patient.
  - Short home visits with doctors and nurses in attendance and later assuming full responsibility.
  - Week-end home visits.
- Definite plans for home care outlined with the patient and the family several months previous to anticipated discharge.

POINTS WHICH DETERMINE PROGRAM

- Pattern of response in serial evaluation of the physiological reserves.
- Fatigue response to carefully regulated breathing, physical and occupational therapy schedules.
- Occurrence and response to intercurrent infections and complications.
- Requirements for further rehabilitation.
- Resources of family and community (financial, emotional, interpersonal relationships, vocational, etc. . . .).
- Availability of medical follow-up and remedial hospitalization.

The ultimate purpose of treatment is decentralization of the patient from special services to home care This should be kept in mind throughout the patient's stay and the foundations for successful weaning of the patient from the hospital should be started upon admission of the patient.

There must be integration and joint participation in the planning for the home care of severe respiratory patients. Each member of the hospital team should be kept informed of the patient's progress within the area of each of the other members of the team Only in this manner is it possible to have consistency and continuity in the attitude presented by each of the staff to the patient and his family. Repetitive reassurance and interpretation from each area is required for the complete adjustment of the patient and his family. Without this underlying philosophy, the structure of the hospital program as well as home care fails

MEDICAL REQUIREMENTS

- Evaluation of the family composition and physical setting of the home to determine the needs of the individual.
- Adaptation of the patient to less expensive and complicated breathing devices.
- Well defined schedule within the patient's tolerance, keeping in mind that the initial phase of home adjustment is fatiguing.
- Complete summary, status report, and outline of medical care to the patient's responsible physician.
- Orientation and instruction of the family and attendant prior to discharge on diet, care, equipment and simplified physical and occupational therapy procedures.
- Insistence on the hazard of intercurrent complications, their signs, etc.
- Periodic re-evaluation as dictated by the patient's individual requirements.

COMMUNITY PARTICIPATION

- Provision of special respiratory and mechanical devices (breathing aids, wheel chair, lifter, emergency generator) and attendant as deemed necessary in cooperation with the financially responsible groups.
- Provision for maintenance and repair of equipment.
- Provision for emergency hospitalization and supplementary respirator aids.
- Evaluation and solicitation of recreational, educational, and vocational facilities.
- Arrangements for transportation to home including vehicle, power, moving of equipment and patient care

ADJUSTMENT OF PHYSICAL SETTING

- Room location and size, door widths, emergency exit.
- Wiring and power.
- Bathroom facilities.
- Bed—type and height.
- Storage space for equipment.
- Provision for going outside the home—ramp, portable breathing aid.

Treatment should not be considered completed upon the patient's discharge from the hospital. Through periodic re-evaluation the patient's program can be supervised and continued at home when maximum benefit from specialized and expensive hospitalization has been reached. Such a plan also gives the patient and family security and self confidence to take on home care. It may be desirable to have "therapeutic" interims at home to neutralize "hospitalitis," to practice learned activities and to gain better emotional adjustment in order to proceed more effectively with intensive rehabilitation at a later date.

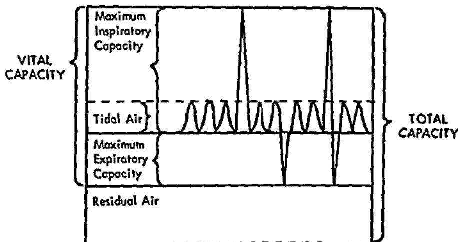
Home care for the severely involved patient demands adequate medical follow-up and the assurance of hospital readmission for intercurrent problems

MEDICAL RESPONSIBILITY DOES NOT CEASE WITH DISCHARGE

APPENDIX

PULMONARY COMPARTMENTS—VITAL CAPACITY

PULMONARY COMPARTMENTS



VITAL CAPACITY: May be taken with any recording BMR, spirometer or ventilation meter in a child over five to six years of age and adults.

- Vital capacity variation may be as much as 1000 cc about a mean value for a particular standard of reference such as age, height, weight, body surface area, etc....
- Decreasing or obviously low vital capacity values are most significant clinically.
- Repeated vital capacity measurements usually demonstrate the decreasing muscle reserve of respiratory paralysis.
- The pattern of the vital capacity maneuver is important in determining whether inspiratory or expiratory capacity is lost and if air trapping occurs.

USE OF TANK ARTIFICIAL RESPIRATION IS USUALLY INDICATED WHEN VITAL CAPACITY DECREASES TO

Adults	1500-1000 cc.
Adolescents	1000- 750 cc.
Children	less than 500 cc.

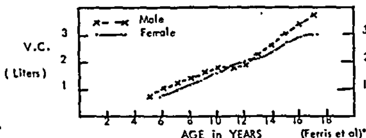
- Eighty per cent of the patients with falling vital capacity will [illegible] artificial respiration eventually.

(low)

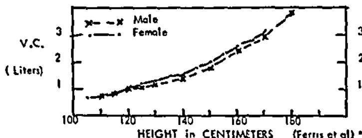
MINIMAL OBSERVED VITAL CAPACITY VALUES IN ADULTS AND CHILDEN

(Values given are 2 s.d.'s below the mean)

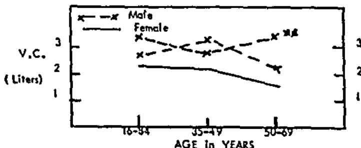
• CHILDREN AND ADOLESCENTS VS. AGE:



. CHILDREN AND ADOLESCENTS VS. HEIGHT :



ADULTS VS. AGE :



(Baldwin, Cournand & Richards)*
(Fowler)**

* and ** See bibliography.

VENTILATORY MEASUREMENTS—TIDAL VOLUMES

TIDAL VOLUME MEASUREMENTS OF SPONTANEOUS QUIET BREATHING ARE FAR TOO VARIABLE TO BE OF CLINICAL USEFULNESS. Factors effecting the significance and accuracy of this measurement include: acute illness, metabolic alterations, apprehension, unsteady state, error and resistance of the device.

TIDAL VOLUMES MEASUREMENTS ON RESPIRATOR PATIENTS ARE EXTREMELY VALUABLE

- For the initial adjustment of respirator pressure.*

Adults	Rate	Tidal Volume	
		Male	Female
Large—200 lbs.	20-12	450-650 cc.	450-550 cc.
Medium—150 lbs.	20-12	400-550 cc.	350-500 cc.
Small—100 lbs	20-12	300-450 cc.	300-400 cc.
Children			
Large—80 lbs.	24-18	225-250 cc.	
Medium—50 lbs.	30-20	140-170 cc.	
Small—35 lbs.	32-25	100-110 cc.	

- For the avoidance of underventilation and excessive ventilation.
- When repeatedly measured at the same pressure setting, since they reflect changes in the condition of the lungs and chest.

DECREASING TIDAL VOLUMES AT THE SAME RESPIRATOR PRESSURE (AND RATE) OCCUR WITH

- Use of endotracheal airway (-20 to 25%).
- Airway obstruction.
- Pulmonary complications such as atelectasis and pneumonitis.
- Circulatory complications such as cardiac failure, pulmonary congestion or edema.

DETERIORATION OF THE PATIENT'S GENERAL CONDITION IS MOST OFTEN THE RESULT OF INADEQUATE PULMONARY VENTILATION

* Values from nomogram prepared for N.F.I.P by Edward P Radford, Jr., M D., Department of Physiology, Harvard School of Public Health.

EXCESSIVE VENTILATION CAN BE DETECTED WHEN THE DEPTH (OR RATE) OF BREATHING IS MUCH LARGER THAN THE ABOVE AVERAGES

- Hypocapnia may produce circulatory alterations such as flushing, tetany, numbness and tingling and general discomfort also may occur.

CORRECTION AND MAINTENANCE OF SALT AND WATER NEEDS

INITIAL REPLACEMENT NEEDS FOR THE DEHYDRATED *POLIOMYELITIS PATIENT**

	NaCl mg./Kg.	Na^+ meq./Kg.	KCl mg./Kg.	K^+ meq./Kg.	Total Water cc./Kg.
	1st 24 hrs.		1st 24 hrs.		1st 24 hrs.
Infant	200-300	3-4 8	200	2 3	150
Child	150	2-3	150	2	120
Adult	100	1-2	70-100	1-1.5	75-90

EXAMPLE:	H_2O in L.	Total Na^+ and	Total K^+ (meq)
10 Kg Infant	1.5	30	23
30 Kg Child	3 6	60-90	60
70 Kg. Adult	6-7	105	85

TYPE OF FLUID SELECTED

- Replace water with 5-10% glucose or invert sugar in water.
- Replace salt with 0.85% NaCl and 0.3% KCl solution.

Composition	Amount	Totals
10% invert sugar in water	60 cc./Kg.	1800 cc.
0 85% NaCl in water	20 cc /Kg	600 cc.
0 3% KCl in 10% invert sugar and water	40 cc./Kg.	1200 cc
	Total	3600 cc.

EXAMPLE.

30 Kg. Child →

Analysis

120 cc. H_2O/Kg /24 hrs.
96 meq of Na^+ as Na^+Cl^-
48 meq. of K^+ as K^+Cl^-

CALORIC REQUIREMENT AT LEAST 40 /Kg./Day—which is at the least maximum protein sparing. (In example above CHO-330 gm. or 11 gm./Kg. or 44 Cal./Kg.)

COMMON EQUIVALENTS (APPROXIMATE)

- 1 gm. Na^+Cl^- = 16 meq. Na^+ or 1 meq. Na^+ = 60 mgm. NaCl.
- 1 gm K^+Cl^- = 13 meq. K^+ or 1 meq. K^+ = 75 mgm. KCl.
- 0.3% KCl = 40 meq. K^+/L or 4 meq. K^+/100 cc.
- 0.85% NaCl = 160 meq. Na^+/L or 16 meq. Na^+/100 cc.

RATE OF FLUID ADMINISTRATION (assuming 15 gtts. = 1 cc.)

- Maximum 4 gtts./Kg/min. for 1-2 hours—then 2 gtts/Kg/min. for 4-6 hours.
- Remainder for even distribution over next 8-12 hours.

IV ROUTE IS PREFERABLE—use Gardner-Murphy polyethylene type needle.

- Calculate 24 hour needs and MIX.

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* Based upon moderately severe dehydration and absence of significant vomiting and diarrhea during therapy.

CORRECTION AND MAINTENANCE OF SALT AND WATER NEEDS

INITIAL REPLACEMENT NEEDS FOR THE DEHYDRATED POLIOMYELITIS PATIENT*

	NaCl mg./Kg.	Na^+ meq./Kg.	KCl mg./Kg.	K^+ meq /Kg.	Total Water cc./Kg.
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EXAMPLE:

30 Kg. Child →

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120 cc. H_2O/Kg /24 hrs.
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- 0.3% KCl = 40 meq. K^+/L or 4 meq. K^+/100 cc.
- 0.85% NaCl = 160 meq. Na^+/L or 16 meq. Na^+/100 cc.

CORRECTION AND MAINTENANCE OF SALT AND WATER NEEDS

MAINTENANCE FLUIDS—AFTER INITIAL REHYDRATION

- NaCl needs less since antecedent deficit now replaced.
- KCl needs remain high due to stress and continuous urinary loss.
- Water needs usually less (unless large urinary volume is noted, especially in adults).
- Average requirements:
  Water—85 cc./Kg./day.
  .85% NaCl—5 cc./Kg./day.
  .3 % KCl—30 cc /Kg./day.
- Given in a 12-14 hour period.

EVALUATION OF PATIENT'S RESPONSE TO THERAPY

- Clinical improvement in hydration, sensorium and pulse.
- Good urine volume with normal specific gravity 1.014-1.020.
- Urine chlorides by Fantus test 3-5 gms. per liter.
- Weight gain of 3-5% in first 24-48 hours.

DANGER POINTS

- Overhydration—watch rate of fluid administration and remember plans are for a 24 hour period.
- Underhydration—is not good when antecedent and current losses are greater than predicted or intravenous administration.
- Potassium intoxication may occur when patient anuric or oliguric.
- Na and Cl retention may result if stress is severe and prolonged.
- Err on side of low sodium intake when in doubt as to patient's needs.

BREATHING EXERCISES

The following is a list of breathing exercises that may be useful for the polio respiratory patient. It will be noted that three types of strengthening exercises are presented:

- Conventional muscle re-education.
- Resistance to the stronger area in an attempt to force breathing in the weaker.
- Pressure or resistance to the desired muscles.

The latter type has been found to be the most effective, but each type has been found valuable in individual patients.

The weaning schedule is used as the primary method for increasing vital capacity, but breathing exercises for strengthening are deemed useful in assisting the patient to become aware of the respiratory muscles and what they do, and thereby gain maximum efficiency from them.

CHEST MOBILITY

USING TANK RESPIRATOR

- Increased negative pressure for maximum inspiration.
- Increased intra-tank positive pressure for forced maximum expiration.
- Abdominal binder to increase thoracic expansion

MANUAL STRETCHING OF THE THORAX, TRUNK AND SHOULDERS

- Neck—all motions in the tank as soon as possible (flexion, rotation, lateral flexion, extension).
- Rotation of trunk in tank respirator using the hips as a lever.
- Lift the chest up and move the chest laterally in the tank respirator.
- Lateral flexion of the trunk—by the hips in the tank and by the shoulders on the bed.
- Trunk flexion—can be started in the tank by raising the hips and later on the bed by raising the shoulders.
- Rotation of trunk on the bed by hips and shoulders.
- Increased shoulder range of motion—particularly flexion and abduction

POSITIONING

- Inter-scapular pillow.
- Slight flexion of the neck and back.
- Abduction of shoulders with pillows, triangles, etc.

MUSCLE RE-EDUCATION

INSPIRATION

Diaphragm

- Concentrate on rise or ballooning of the abdomen on inspiration eliminating accessory breathing
- Manual resistance on upper chest to force diaphragmatic breathing.
- Put diaphragm on a stretch—maximum expiration plus thumb pressure up and under costal angles attempting to gain rebound and give the patient a sensation of where to contract.
- Resist the descent of the diaphragm by thumb pressure up and under anterior rib cage.
- Place the patient in Trendelenburg and have him use the diaphragm against the resistance of the abdominal contents. Additional hand pressure may be used.
- Sniffing.

Lateral Chest

- Consciously hold back on the accessories and attempt lateral expansion.
- Manual pressure to lateral chest utilizing stretch and kinesthetic sense.
- Manual resistance to lateral chest.
- For unilateral deficiencies:
    - a) Resist the better side and force breathing in the opposite.
    - b) Resist both sides holding back on the better side.
    - c) Manual pressure to the weak side.
- Patients with the use of hands and some ability to take resistance to inspiration:
    - a) Resist self with strap around chest.
    - b) Push up against lateral chest and give self resistance.

Upper Chest

- Consciously eliminate accessories and attempt to gain chest rise.
- Manual pressure over sternum or pectoral areas for resistance and/or kinesthetic sense.
- Manually resist and hold back on the abdomen and attempt to force upper chest breathing.

General

- Inspiration above the aid of the respirator.
- Strengthen accessory muscles of breathing by muscle re-education other than breathing exercises

- Patient push down with the head on the bed frequently and as soon as possible to maintain and increase strength of the posterior neck and back extensors used in stabilizing the head for accessory neck breathing.
- Manually resist chin and/or forehead and have the patient breathe in.

EXPIRATION

- Strengthen abdominals, lattissimus dorsi by re-education other than expiratory exercises.
- Emphasize forced expiration:
  - Hissing, humming, whistling, singing.
  - Cough at the end of a maximum expiration.
  - Blow against resistance—soap bubbles, sailboat, whistles, ping pong ball, blow bottle, balloon.
  - Manual assistance over lower ribs and abdomen to gain more expiration. Patient can be taught to do this if upper extremities are strong enough.

JOINT RANGE OF MOTION

NECK

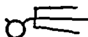
1. **Flexion:** Lift the head bringing the chin up to the chest.



2. **Lateral Flexion:** Move the head laterally bringing the ear to the shoulder.



3. **Rotation:** Rotate the head turning the face completely to the left and then to the right.
4. **Extension:** Extend the neck. This can only be done in the side-lying or face-lying positions or if the patient is in the tank respirator, it can be done by lowering the head piece.

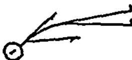



TRUNK

1. **Flexion:** Flex the back by raising the head and shoulders bringing the head towards the knees.




2. **Lateral Flexion:** Place your arm under the patient's neck and your hand under the opposite scapula. Pull the patient toward you laterally flexing the trunk. Hold the opposite hip down if he starts to move as a whole.



3. **Lateral Flexion in Tank Respirator:** Support both legs with one hand under the thighs and the other under the ankles and pull the legs and hips toward you.

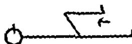


4. **Rotation:** Place one hand on the pelvis on the far side and the other under the scapula. Hold the pelvis down and rotate the upper trunk toward you in a twist.

5. Rotation in the Tank Respirator: Cross the far leg over the near leg. Place one hand under the hip and the other on the far shoulder. Hold the shoulder down and pull the hip over toward you twisting the trunk.

HIPS

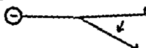
1. Flexion: Place one hand under the knee and one under the ankle. Flex the hip and knee bringing the knee toward the chest.



2. Hamstrings and Quadriceps: Flex the hip to 90° and hold it there. Extend the knee and then flex it by lifting at the ankle.



3. Abduction: With one hand under the knee and one under the ankle move the leg out to the side to a 45° angle.



4. Rotation: Place one hand on the knee and one on the foot. Roll the leg in and then roll it out.

FOOT

1 Dorsi and Plantar Flexion: Place one hand on the heel and the other on the forefoot. (a) Pull the heel down and push the forefoot up and (b) Pull the forefoot down and push the heel up.



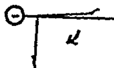
2. Inversion and Eversion: Place one hand on the leg just above the ankle and the other on the forefoot. Turn the foot in and out.
3 Toe Flexion and Extension: Place one hand on the forefoot and the other over the toes. Bend the toes down and then bring them back straight.

SHOULDER

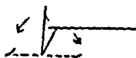
1 Flexion: Place one hand under the elbow and one supporting the hand Raise the arm straight up and bring it back toward the bed.



2. Abduction: Using the same holds take the arm out to the side to a 90° angle.



3. Rotation: Place the arm in abduction and flex the elbow to 90°. Maintain this position of the shoulder and elbow and take the hand back toward the bed. Then move it forward in an arc toward the bed.



ELBOW

1. Flexion and Extension: Hold at the wrist and flex the elbow bringing the fingers to the shoulder then straighten the elbow.



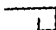
2. Supination—Pronation: Hold the elbow flexed to 90°. Then turn the hand so that the palm is toward the face and then turn it in and around toward the feet.

WRIST

1. Flexion—Extension: Hold the elbow flexed to 90° and then flex and extend the wrist.
2. Abduction—Adduction: With the elbow flexed to 90° move the wrist medially and laterally.

FINGERS

1. Flexion: Flex the elbow to 90° and hold at the wrist to keep it from moving. Place your other hand over the dorsum of the fingers and curl them down into the palm. Each of the three joints normally goes to a right angle.



2. Extension: Using the same positions straighten the fingers.
3. Abduction: Spread the fingers apart and then bring them together

THUMB

1. Flexion: Bring the thumb across the palm of the hand to the base of the little finger.
2. Extension: Bring the thumb back to a right angle with the palm.
3. Abduction: Bring the thumb directly forward from the forefinger.
4. Opposition: Touch the tip of the thumb to the tip of the little finger.

GENERAL EVALUATION OF MUSCLE STRENGTH

The following procedures may be done in five minutes or less for general detection of weakness in muscle groups. Muscles will appear to be weak or flaccid if there is an increase of tonus (spasm) in the antagonist. Range of motion should be checked passively so that an erroneous picture of weakness is not obtained.

Resistance is given just to the point where the muscle gives. A normal muscle—regardless of age, weight, etc—has a "spring back" feeling while weak muscles play out with resistance.

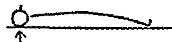
If the patient is unable to move the part into the desired position the muscles are probably weak, but not necessarily flaccid. Assist the motion and ask if the patient can hold it. Observation and palpation of muscle bellies and tendons is valuable throughout.

COMPLETE CHECK IN THE SUPINE POSITION

STERNO-CLEIDO-MASTOIDS (and accessory neck flexors) and ABDOMINALS: The patient raises the head and shoulders up from the bed and looks at the feet. Resist the head and palpate the abdominals. (Note: this is often difficult or impossible with increased tonus of the erector spinae. Abdominal strength can be estimated by palpation during forced expirations as in coughing or by resisting leg raising.)



ERECTOR SPINAE (cervical, thoracic and lumbar): Place your hand under the patient's head and have him hold down while you try to raise him up. Patient should be able to hold the back rigid with muscles of 70% and above strength. (Note, this is not a very accurate test since most patients have "increased muscle tonus" in this group. A more accurate measurement can be found with the patient in the prone position.)

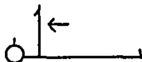


SHOULDER: Have the patient raise the hand and arm and point to the ceiling Resist in four directions—flexion, extension, abduction, and adduction

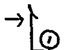
1 Flexion: ANTERIOR DELTOID, CORACOBRACHIALIS



2. Extension: LATISSIMUS DORSI, TERES MAJOR, POST. DELTOID



3. Abduction: MIDDLE DELTOID, AND SCAPULAR ADDUCTORS (MIDDLE TRAPEZIUS, RHOMBOIDS)



4. Adduction: PECTORALIS MAJOR



ELBOW: Patient bends the elbow. Resist in two directions and rotation.

1. Flexion: BICEPS BRACHII, BRACHIALIS, BRACHIORADIALIS



2. Extension: TRICEPS BRACHII



3. Pronation: PRONATOR TERES, PRONATOR QUADRATUS. Patient turns the palm toward the feet, resist in the opposite direction.
4. Supination: SUPINATOR BREVIS, BICEPS BRACHII. Patient turns palm toward face, resist in the opposite direction.

WRIST AND FINGERS

1. Extension: EXTENSOR CARPI RADIALIS AND ULNARIS, EXTENSOR DIGITORUM COMMUNIS, EXTENSOR POLLICIS LONGUS AND BREVIS.

   Have the patient extend the wrist and spread the fingers. Resist the fingers.



2. Flexion: LUMBRICALES, FLEXOR DIGITORUM SUBLIMUS, FLEXOR DIGITORUM PROFUNDUS, FLEXOR CARPI RADIALIS AND ULNARIS.

   Place your fingers in the patient's hand, have him close his fingers in a fist, resist by trying to open the hand

THUMB

OPPONENS POLLICIS, ABDUCTOR POLLICIS LONGUS AND BREVIS, FLEXOR POLLICIS LONGUS AND BREVIS.

Have the patient touch the tip of the thumb to the tip of the little finger. Resist by pulling the thumb and little finger apart. (Note. for true opposition the thumb nail should be parallel to the palm.)

HIP

Resist in four directions--flexion, extension, abduction, and adduction.

1. Flexion: ILIOPSOAS, SARTORIUS, RECTUS FEMORIS.

Have the patient raise the leg straight up from the bed. Resist toward the bed. (Note: if the patient can raise the leg, the muscles are 50% or better.)



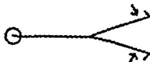
2. Extension: GLUTEUS MAXIMUS, HAMSTRINGS.

Have the patient attempt to hold the leg on the bed while you try to lift it up (Note: normally he should be able to hold it stiff and you should be able to lift him as a unit up to his upper back or head.)



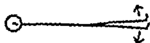
3. Abduction: GLUTEUS MEDIUS AND MINIMUS, TENSOR FASCIAE LATAE.

Place the patient's legs in abduction, have him hold them while you try to push them in. This can be done well bilaterally.



4. Adduction: ADDUCTOR MAGNUS, LONGUS, BREVIS, PECTINEUS.

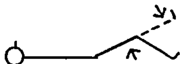
Have the patient try to hold the legs together while you pull the legs apart.



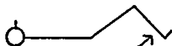
KNEE

Support the thigh in 20 to 40 degrees of flexion. Resist extension and flexion.

1. QUADRICEPS FEMORIS—The patient extends the knee, resist at the foot.

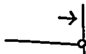


2. HAMSTRINGS—The patient bends the knee and you resist the motion.



FOOT, ANKLE, AND TOES

1. Dorsi Flexion: TIBIALIS ANTERIOR, EXTENSOR DIGITORUM LONGUS, EXTENSOR HALLUCIS LONGUS. Have the patient dorsiflex the foot, try to push it into plantar flexion.



2. Plantar Flexion: GASTROCNEMIUS AND SOLEUS. The patient pushes the foot down, try to push it into dorsi flexion. (Note: if this muscle gives because of weakness, marked involvement is present.)



3. Inversion: TIBIALIS POSTERIOR, TIBIALIS ANTERIOR. Have the patient swing the foot down and in, resist in the opposite direction.
4. Eversion: PERONEUS BREVIS AND LONGUS. Have the patient swing the foot down and out, resist by pushing the foot in.
5. Toe Extension: EXTENSOR DIGITORUM LONGUS AND BREVIS, EXTENSOR HALLUCIS LONGUS. The patient extends the toes —resist toward flexion
6. Toe Flexion: FLEXOR DIGITORUM LONGUS AND BREVIS, LUMBRICALES, FLEXOR HALLUCIS LONGUS AND BREVIS. The patient curls the toes and you try to open them.

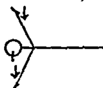
OTHER USEFUL CHECKS IF THE PATIENT CAN ASSUME POSITIONS

PRONE POSITION

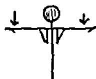
1. ERECTOR SPINAE (CERVICAL, THORACIC AND LUMBAR), GLUTEUS MAXIMUS AND HAMSTRINGS. Have the patient raise the head and shoulders from the bed and legs if possible. Resist at the head and heels and check where the patient breaks. (Note: at least 50% muscles are needed to do this without resistance.)



2. MIDDLE AND LOWER TRAPEZIUS, RHOMBOIDS AND POSTERIOR DELTOID. Arms in abduction—the patient keeps the head on the bed and raises the arms up. (Note: 50% or better muscles are needed to do this.) Resist at the wrists.



SITTING OR STANDING: DELTOID, TRAPEZII, RHOMBOIDS
Have the patient abduct both arms, resist at the wrists and view from the back.



STANDING

1. GLUTEUS MEDIUS: The patient stands on one leg. If the pelvis drops on the opposite side (positive Trendelenburg) or the trunk shifts to the same side, there is marked weakness of the Gluteus Medius



2. GASTROCNEMIUS-SOLEUS

   Have the patient stand on one leg and rise up on that toe There is marked weakness if he cannot do this.



3. Have the patient squat down on the heels and rise to the standing position without using the hands. Children and young adults can normally do this but if there is any weakness in the legs, particularly the QUADRICEPS, AND GASTROCNEMIUS-SOLEUS, they will lose their balance or be unable to go all the way down.



WALKING weakness or tightness of each individual muscle group in the lower extremities and trunk causes a particular type of gait. Usually this is communicated to hip position. Watch for dropping of the pelvis, shifting of the trunk laterally, anteriorly, or posteriorly over the stance leg, locking of the knee on stance, slapping of the foot. New polios do not walk in hip and knee flexion and it is also unusual for them to walk stiff-legged.

Weakness in the feet can be checked readily by having the patient walk on the toes (view from behind) and walk on the heels (view from the front).

Optimum use of equipment such as cuirass respirators and rocking beds depends largely upon the experience and proficiency of the personnel and adequate mechanical maintenance. Operation is best demonstrated by bedside instruction and participation. The absolute necessity of familiarity with equipment cannot be overemphasized for its successful employment in the care of the convalescent respirator patient. Cuirass respirators have been utilized for brief periods for nursing care and physical therapy in the earliest afebrile phases in the uncomplicated patient. In general cuirass respirators and rocking beds have not been utilized as a primary breathing aid at the onset of respiratory muscle paralysis because there is little doubt that they have less maximum ventilatory effectiveness than the tank respirator.

The following section on the maintenance and specifications of commonly used respiratory equipment is based upon the experience of a Respiratory Center and the Equipment Maintenance Pool of the National Foundation for Infantile Paralysis, Inc., at Jefferson Davis Hospital.

The section is intended to highlight important general information not readily available. It is not complete nor can it be since any single experience will not include all of the different types of equipment available throughout the entire country. An example is intermittent positive pressure breathing apparatus

This material must not be considered either an endorsement or a criticism of a particular manufacturer's product. The majority of the manufacturers continuously modify or alter equipment, based upon experiences reported by users. Thus descriptions of apparatus cannot keep pace with changes. These suggestions, however, apply to currently available apparatus.

This information has been included in the syllabus because proper operation and maintenance of respiratory equipment is obviously of the utmost importance for the successful medical care of the respirator patient.

GENERAL CONSIDERATIONS IN MAINTENANCE OF RESPIRATORY EQUIPMENT

UNDERSTAND THE MACHINE BEFORE MAINTENANCE OR REPAIRS ARE ATTEMPTED!

- Always read the manual of instructions and follow the lubrication instructions.
- Do not over oil the motors.
- Keep the equipment clear of the walls and furniture to prevent moving parts from being damaged.
- Avoid the use of other large electrical appliances on the same circuit.
- Promptly replace worn or defective plugs and cut or bruised cords.
- Keep a lamp or circuit tester available in order to check quickly the outlet for power.
- Know in advance the position of an alternate outlet on another circuit.
- Lock or block the casters before working on equipment.

CAUTIONS

- Do not attempt to repair or lubricate machines while they are in operation—injuries and damage to equipment will result.
- Do not leave machine plugged in circuit even though switch is off. Some wiring is exposed and electrical shock can occur.

PREVENTIVE MAINTENANCE IS CHEAPER AND SAFER THAN EMERGENCY REPAIR!

TANK RESPIRATOR

TO CHECK OPERATION OF TANK RESPIRATOR

Place a piece of cardboard or a pillow in the head opening. Turn on the motor and adjust valve to increase negative pressure. The gauge should record at least a maximum negative pressure of 28-30 cm. of water at a rate of 20 strokes per minute.

COMMON FAILURES AND THEIR CORRECTION

INSUFFICIENT NEGATIVE PRESSURE

- On tanks check for leaks around portholes, collar, extra outlets, cot adjusting handles. In cuirass respirators check hoses and shells.
- Negative pressure release valve sometimes sticks in the open position.
- If gauge does not move, check connecting hose to gauge, if present.
- Head end gaskets will go bad, but more often there is a towel, sheet or strap preventing an adequate seal.

EXCESSIVE POSITIVE PRESSURE—usually is caused by an inboard leak on the negative stroke.

- Look for leaks allowing too much air to be drawn into the respirator on the negative stroke and which cannot be exhausted on positive stroke. Maximum negative pressure will be decreased.
- Sometimes the positive valves stick closed or connecting rods and handles come loose and do not open the valve. Find the valve to which the control connects and turn this valve by hand in an emergency.

MOTOR FAILURE—Is not usually due to a burned out motor on the tank respirator.

Check the following things first.

- Belt in place.
- Electric plugs for tightness of connection (Emerson has extra plugs on motor).
- Plug a floor lamp into the plug on the side of the tank. If light operates, current has traveled to the switch on the tank. If light fails to operate, tank connecting electrical cord may be faulty or damaged by moving parts.
- Then plug electric lamp into the plug on the motor. If lamp lights when switch is on, the short is between motor plug and motor. If lamp fails to light, the trouble is in the switch.
- Motor Failure—have replacement motor available.

SPECIFICATIONS OF COMMONLY USED RESPIRATORY EQUIPMENT

EMERSON TANK RESPIRATOR

Power: 110 V AC 60 cycle.

Motor: 1/3 HP 5.6 Amps plus 60 W electric light in tank and accessory plug.

Weight: 700 pounds.

Width: 32½"—by removing cot clamps, a width of 30½" can be achieved

Height: 61"—remove gauge and it will be 55".

Length: 96"—shortened 3" by removing head rest.

Lubrication: Instructions are on the side of the tank near the gauge.

DRINKER COLLINS ADULT TANK RESPIRATOR

Power: 110 V AC 60 cycle.

Motor: ¼ HP 4.2 Amps plus 40 W light with guard in tank.

Weight: 608 pounds.

Width: 31½".

Height: 58½".

Length: 75¼".

Lubrication: Instructions are on the side of the machine.

MAINTENANCE SUGGESTIONS

- Connecting hose can be replaced with automobile windshield wiper hose on models where gauge is on the side panel.
- Arm port doors often leak. In an emergency more pressure can be obtained with shims under the clip that holds the port shut.
- Failure to change rate is usually due to failure of the split pulley. Apply lubricant to pulley so that it works freely and separates easily.

MONAGHAN HOSPITAL MODEL CUIRASS RESPIRATOR

Power: 110 V AC 60 cycle.

Motor: 1/6 HP 3.4 Amps.

Weight: 200 pounds crated.

Width: 20".

Height: 37".

Length: 40".

Lubrication: Follow instructions in back door panel.

MAINTENANCE SUGGESTIONS

- To eliminate noise on pulley at gear case, apply one drop of oil on stationary end of end bearing surface while motor is stopped.
- To eliminate squeak of belt, apply two eye droppers of any standard

brake fluid to inside surface of belt while motor is stopped.

- For any other maintenance, see manual or call nearest dealer.

DO NOT PUT HANDS INSIDE MACHINE WHILE MOTOR IS OPERATING!

HUXLEY CUIRASS RESPIRATOR

UNIT

Power: 110 V AC.
Weight: 96¾ pounds.
Width: 17".
Height: 25".
Length: 16".

BATTERY

Weight: 69½ pounds.
Width: 9¾".
Height: 10"
Length: 17½".

RECTIFIER

Weight: 39¾ pounds.
Width: 10¾".
Height: 12".
Length: 20".

GENERAL DESCRIPTION

This respirator comes in a standard 110 V AC unit to operate on ordinary house current and in a battery rectifier operated unit (4-5 hours) for the purpose of transporting patients or as a safety measure for power failure.

The power unit and respirator are basically the same. It uses a motor and gear box to move a piston in a cylinder through a complete cycle thus developing both positive and negative pressure. Valves are controlled by knobs on top to adjust negative and positive pressure.

The speed is regulated by changing the motor pulley ratio by using the knob on the side of the unit. An electrical speedometer indicates the respirations per minute on the top of the machine

The 24 volt unit will operate from ordinary house current, 110 V AC 60 cycles, when used with the rectifier and batteries. Simply plug the rectifier into a wall outlet, plug battery and respirator into rectifier and it works the same as a straight 110 V AC unit The rectifier and battery should be plugged into the wall outlet at all times, even if the unit is not being used, to maintain a full battery charge

MAINTENANCE SUGGESTIONS

Read the instruction book.

Oil Leaks

- There should be a breather cap on top of the gear box. If not, one should be secured from the manufacturer. If it has a breather and leaks, obtain a new gear box.

Insufficient Negative Pressure

- There is often a leak at the shell. Careful fitting of the shell is required. Repositioning of the patient may produce a shell leak. Other causes of insufficient negative pressure may be due to a bad gauge, a hole in the bellows, sticking of the relief valve on the bottom of the bellows in the open position, or failure of the knob to operate the negative pressure valve.
- To make a simple check of the negative pressure adjustment valve with the machine running, turn valve to decrease and listen closely, then turn completely to the other extreme and a change should be heard. If the plastic knob has become loose on its shaft, remove it and manually turn the shaft until the knob can be replaced. If it is the valve which is broken, consult the manual for this is a major repair.
- Leaks in the bellows of the earlier models can be detected by noting the frayed edges on the bellows and the sound of escaping air. Adhesive tape will seal it until arrangements for a repair can be made.

Other Problems

Thumping noises are usually caused by two things: (1) articles falling into the outlet for the hose connection. If they cannot be easily removed, obtain an exchange machine before too much damage is done. (2) Gear case wear will cause the machine to thump after it has made its up stroke and starts down. To find this fault (keeping the hands and tools out of the machine while it is run- [illegible] gear case can be changed without any great difficulty by a mechanic.

Power failures seldom occur unless there is a defective cord or a damaged plug.

UNIVERSAL MODEL MONAGHAN PORTABLE CUIRASS RESPIRATOR

Model 100A, 103 and 115A

Power: 110 V AC 60 cycle house current or 24 V batteries for 3½ hour trips. Other voltage characteristics can be supplied by factory.

Weight: 52½ pounds.

Width: 12".

Height: 16".
Length: 33½".

BATTERY
Weight: 33½ pounds.
Width: 8".
Height: 8".
Length: 16".

RECTIFIER AND BATTERY PACK
Weight: 43½ pounds
Width: 8".
Height 11".
Length: 16".

General Instructions: In black and white lettering bolted to front of machine

GENERAL DESCRIPTION

There is a dial type gauge on the front of the machine reading from 0 to 60 pressure and 0 to 60 vacuum in millimeters of mercury. When attached by a small hose to the shell, it gives actual pressure at the shell (chest).

This machine operates from a ½ HP, high speed, 24 V centrifugal blower with utilization of both suction and pressure outlets. The pressure is changed from positive to negative by the means of a four way valve operated by an electric solenoid. Rate and per cent of cycle occupied by inspiratory negative pressure are timed by an electronic device. The amount of positive or negative pressure is determined by the amount of leak to the atmosphere through ports operated by adjusting knobs similar to those on other respirators

It is well to note that the hand operation is simple but the hose must be moved from its normal fitting and inserted in the emergency fitting on the front opposite end from the normal fitting Then simply pull the red handle up and down at the desired rate

MAINTENANCE SUGGESTIONS

- Study the manual BEFORE repairs become necessary.
- In rough handling or on land trips electronic components may vibrate loose. It is simple to change tubes and relays since radio tube connections are used. These parts are located on the back of this machine at the upper left. Each one will fit only in the proper socket. Check to see that the connections are tight.
- To change brushes in this machine, read the manual or the instructions which come with the new brushes. They will last a long time if installed properly

CAUTIONS

- Do not cover the ventilation holes on the outside of this machine with pillows or sheets, otherwise overheating and damage readily occur.

- Do not check the gauge by closing your hand over the hose as the excessive pressure will break the gauge.
- As with any chest respirator, keep small children from dropping small articles in the hose outlets. Results can be ,amazing. Coins, bobby pins, even paint brushes have been removed from many chest respirator machines. This hazard applies to all models by any manufacturer.

BURNS ROCKING BED

Power: 110 V AC 60 cycle.
Motor: 1/3 HP 5.6 Amps
Weight: 300 pounds.
Width: 37"—can be laid on side and will go through 30" door.
Height: 32"—without mattress.
Length: 78".
Lubrication: Use a few drops of light electric motor oil on motor each month. Use automobile transmission oil on gear case. Keep level to side plug on gear case.

EMERSON ROCKING BED

Power: 110 or 230 V. Normally 110 V AC 60 cycle unless ordered special. Power consumption at 110 V—8.8 Amps (starting load 17 Amps).
Plug: 2 prong standard plug with ground wire clip.
Weight: 865 pounds crated.
Width: 39"—will go through a 36" door by removing one handle
Height: 39"—including mattress.
Length: 79".
Lubrication: Grease all parts on bed where grease fittings are found, once per month. Oil motor very sparingly once a month using light electric motor oil. The pulley on the gear case should be greased very sparingly or it will cause grease to sling out onto the drive belt. Oil should be kept up to and not above side plug on gear case. Use a transmission oil 600 W or equal.

CAUTION

Bed should be blocked so that it cannot creep while it is in motion thereby striking on a piece of furniture and causing damage to the end, other furniture and the patient.

NEVER ATTEMPT TO REPAIR OR LUBRICATE A BED WHILE IT IS OPERATING!

AMERICAN HOSPITAL—TOMAC—ROCKING BED

Power: 110 V AC.
Motor: ¾ HP 10 Amps—should be fused with 30 Amp. fuses.
Width: 37¾″.
Height: 36″.
Length. 79½″.
Lubrication: Speed reducer or gear box—keep oil to overflow with 600 W or equal oil.
Grease: Worm gear assembly and oil bearing—use Keystone 45 grease or equal and light 10 SAE oil on oil fitting.

GENERAL DESCRIPTION

- Tilting plane—from 0° to 10° of the foot end below horizontal and 0° to 5° above horizontal
- Speed—of bed ranges from 10 to 30 complete oscillations per minute.
- Degree of tilt—of bed is variable from 0° to 30° above and below horizontal.

This piece of equipment is of very sturdy construction and is identical in principal of operation to other rocking beds Variation of frequency of tilt, relation of tilt to horizontal and degree of tilt is accomplished in a different fashion with controls in unusual locations

MAINTENANCE SUGGESTIONS

This piece of equipment appears to have few mechanical problems when it is lubricated as per instruction manual. Decreased clearance of bed frame and under frame due to the wear or movement of adjusting nuts holding the bed frame to the eccentric connecting link may be corrected by tightening the nuts from time to time. If bed is not so equipped, the top retaining nut can be replaced with an automotive nut and cotter key and be used to hold a proper adjustment.

A check for tightness of all socket head set screws will prevent their working loose If adjusting handles work loose, it may be necessary to drill some shafts to make a hole to retain set screw locking action

CAUTIONS

- Do not work on the under part of a rocking bed while it is plugged into power All manufacturers expect you to use this safety measure on their equipment.
- Keep chairs and other furniture clear as, with all rocking beds, damage to bed, furniture and patient can occur

- Do not check the gauge by closing your hand over the hose as the excessive pressure will break the gauge.
- As with any chest respirator, keep small children from dropping small articles in the hose outlets. Results can be amazing. Coins, bobby pins, even paint brushes have been removed from many chest respirator machines. This hazard applies to all models by any manufacturer.

BURNS ROCKING BED

Power: 110 V AC 60 cycle.
Motor: 1/3 HP 5.6 Amps.
Weight: 300 pounds.
Width: 37″—can be laid on side and will go through 30″ door.
Height: 32″—without mattress.
Length: 78″.
Lubrication: Use a few drops of light electric motor oil on motor each month. Use automobile transmission oil on gear case. Keep level to side plug on gear case.

EMERSON ROCKING BED

Power: 110 or 230 V. Normally 110 V AC 60 cycle unless ordered special. Power consumption at 110 V—8.8 Amps (starting load 17 Amps).
Plug: 2 prong standard plug with ground wire clip.
Weight: 865 pounds crated.
Width: 39″—will go through a 36″ door by removing one handle.
Height: 39″—including mattress.
Length: 79″.

Lubrication: Grease all parts on bed where grease fittings are found, once per month. Oil motor very sparingly once a month using light electric motor oil. The pulley on the gear case should be greased very sparingly or it will cause grease to sling out onto the drive belt. Oil should be kept up to and not above side plug on gear case. Use a transmission oil 600 W or equal.

CAUTION

Bed should be blocked so that it cannot creep while it is in motion thereby striking on a piece of furniture and causing damage to the end, other furniture and the patient.

NEVER ATTEMPT TO REPAIR OR LUBRICATE A BED WHILE IT IS OPERATING!

AMERICAN HOSPITAL—TOMAC—ROCKING BED

Power: 110 V AC.
Motor: ¼ HP 10 Amps—should be fused with 30 Amp. fuses
Width. 37¼″.
Height: 36″.
Length: 79¾″.
Lubrication: Speed reducer or gear box—keep oil to overflow with 600 W or equal oil.
Grease: Worm gear assembly and oil bearing—use Keystone 45 grease or equal and light 10 SAE oil on oil fitting.

—NERAL DESCRIPTION

- Tilting plane—from 0° to 10° of the foot end below horizontal and 0° to 5° above horizontal
- Speed—of bed ranges from 10 to 30 complete oscillations per minute.
- Degree of tilt—of bed is variable from 0° to 30° above and below horizontal.

This piece of equipment is of very sturdy construction and is identical in principal of operation to other rocking beds. Variation of frequency of tilt, relation of tilt to horizontal and degree of tilt is accomplished in a different fashion with controls in unusual locations.

MAINTENANCE SUGGESTIONS

This piece of equipment appears to have few mechanical problems when it is lubricated as per instruction manual. Decreased clearance of bed frame and under frame due to the wear or movement of adjusting nuts holding the bed frame to the eccentric connecting link may be corrected by tightening the nuts from time to time. If bed is not so equipped, the top retaining nut can be replaced with an automotive nut and cotter key and be used to hold a proper adjustment.

A check for tightness of all socket head set screws will prevent their working loose If adjusting handles work loose, it may be necessary to drill some shafts to make a hole to retain set screw locking action.

CAUTIONS

- Do not work on the under part of a rocking bed while it is plugged into power. All manufacturers expect you to use this safety measure on their equipment.
- Keep chairs and other furniture clear as, with all rocking beds, damage to bed, furniture and patient can occur

McKESSON RESPIRAID ROCKING BED

Power: 110 V AC.
Motor: Direct current motor operated from rectified 110 V AC supply. Maximum consumption 24 Amps.
Weight: 550 pounds.
Width: 40″.
Height: 50″.
Length: 78″.

GENERAL DESCRIPTION

This bed consists of a platform operating on a curved sector with a matching base support. Control of the bed is accomplished by a direct current motor of variable speed and there is provision for continuous adjustment of extent of inclination through a motor driven variable length offset arm. This type of control requires an elaborate rectifier which was accomplished by vacuum tubes in earlier models and by selenium rectifiers in later models. Operation of the bed is adequately described in the manufacturer's literature. Maintenance problems have been concerned with electronic power supply of the first models and mechanical considerations similar to other rocking beds. Frequency of oscillations is adjustable up to thirty times per minute.

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